EXHIBIT 51

United States Patent [19]

Freeman et al.

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[54] SYSTEM AND METHOD FOR ELECTRONICALLY RECORDING AND PLAYING BACK VIDEO IMAGES WITH IMPROVED CHROMINANCE CHARACTERISTICS USING ALTERNATE EVEN AND ODD CHROMINANCE SIGNAL LINE MATRIX ENCODING

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[51] **Int. Cl.**[4] **H04N 9/79; H04N 9/67**

[52] **U.S. Cl.** **358/313**; 358/30; 358/906; 360/33.1; 360/35.1

[58] **Field of Search** 358/310, 313, 314, 320, 358/330, 335, 906, 909, 30, 41, 44, 12, 14, 244; 360/33.1, 35.1, 9.1, 11.1

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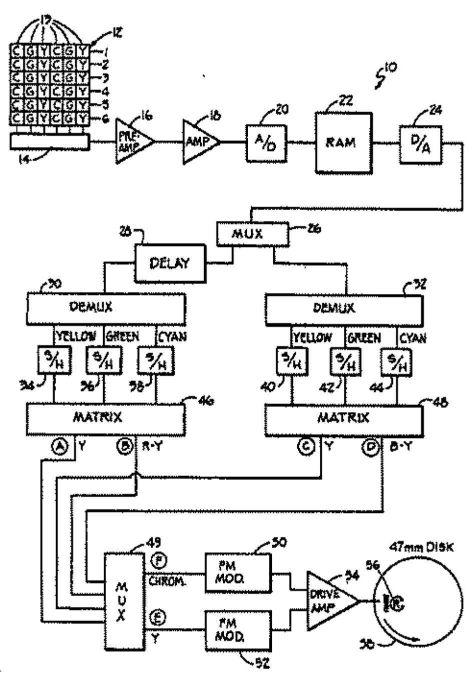
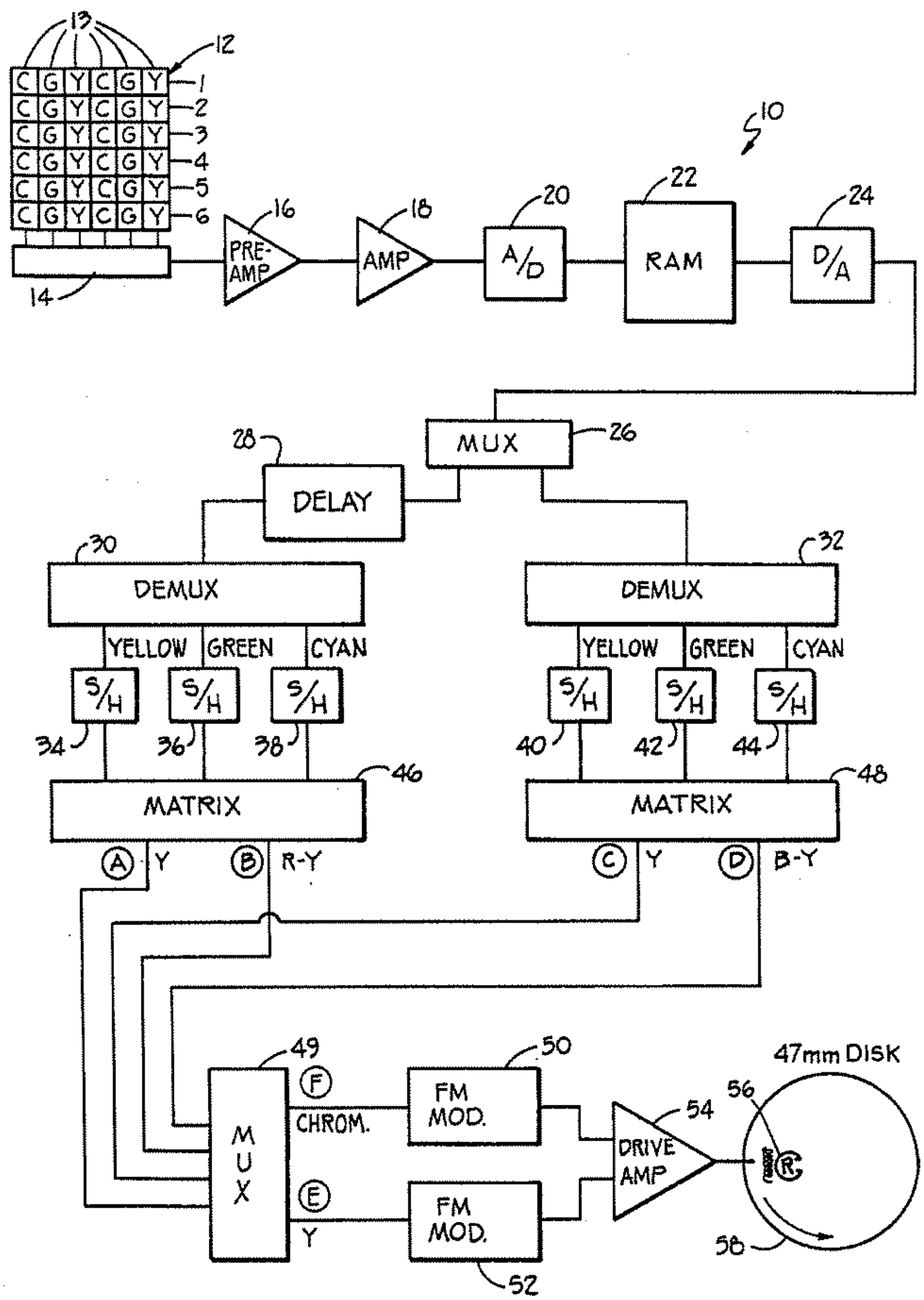
[57] **ABSTRACT**

Apparatus and method for encoding and recording electronic image information signals in a manner whereby luminance signals for odd field lines are recorded in association respectively with chrominance signals alternately selected from both the even field lines and the odd field lines and luminance signals for even field lines are recorded in association respectively with the remaining chrominance signals alternately selected from both the even field lines and the odd field lines. Chrominance samples recorded in this manner are spaced only two field lines apart thereby allowing the chrominance signals to be interpolated by a playback device specially configured to provide for increased vertical chromianance resolution. Chrominance samples recorded in this manner may also be played back with a conventional playback device, which does not provide the increased vertical chrominance resolution while such a specially configured playback device can play back chrominance samples recorded in standard format without providing the increased vertical chrominance resolution.

28 Claims, 2 Drawing Sheets





13
12
C G Y C G Y
1
2
3
4
5
6
10
14
16
PRE-AMP
18
AMP
20
A/D
22
RAM
24
D/A
26
MUX
28
DELAY
30
DEMUX
32
DEMUX
YELLOW
GREEN
CYAN
S/H
34
36
38
40
42
44
46
48
MATRIX
A
Y
B
R-Y
C
D
B-Y
49
F
CHROM.
E
M U X
50
FM MOD.
52
54
DRIVE AMP
56
47mm DISK
58

FIG 1

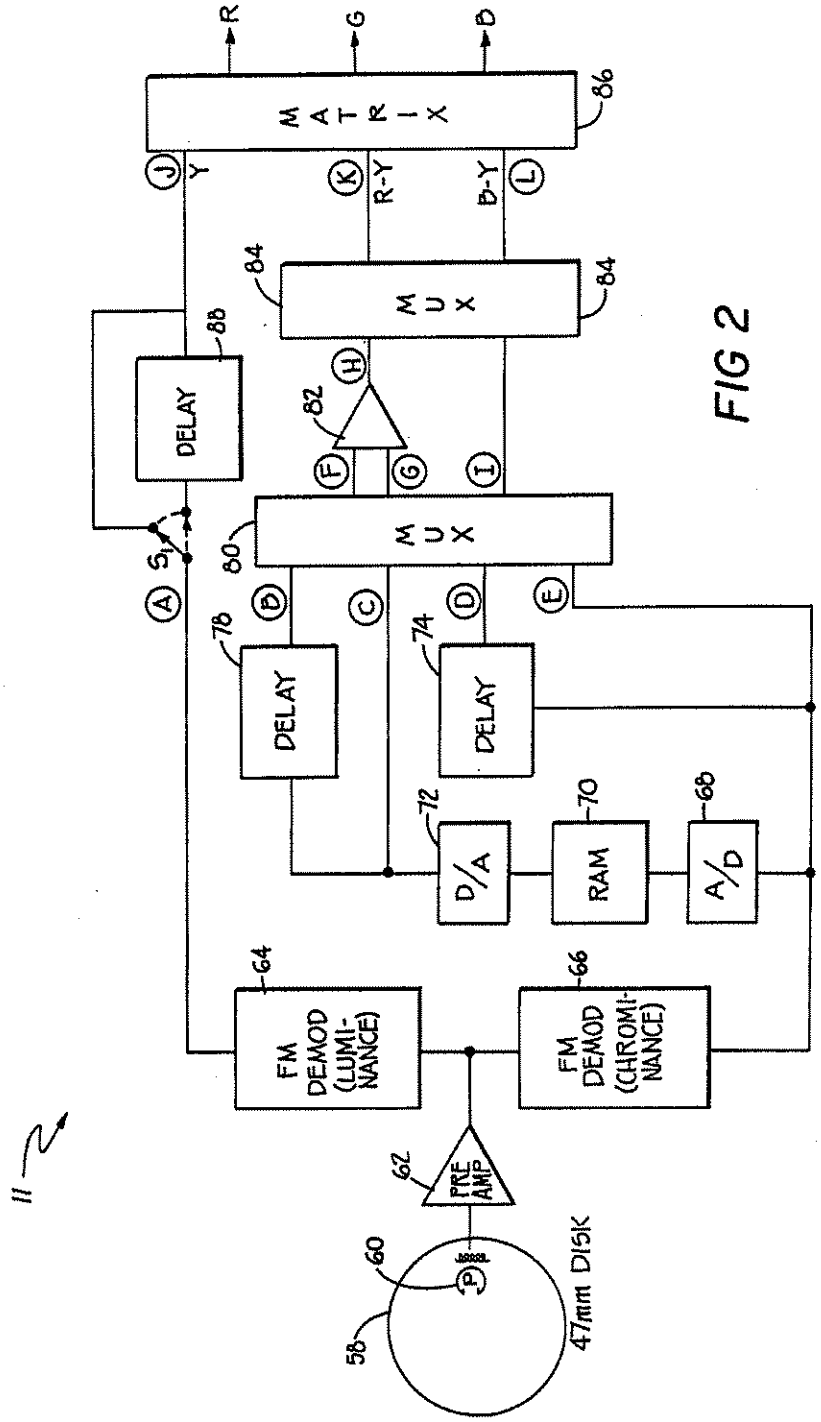

R
G
B
MATRIX
86
J
Y
K
R-Y
B-Y
L
84
MUX
84
88
DELAY
H
82
F
G
I
80
MUX
A
S1
B
C
D
E
78
DELAY
74
DELAY
72
D/A
70
RAM
68
A/D
64
FM DEMOD (LUMINANCE)
66
FM DEMOD (CHROMINANCE)
62
PRE AMP
60
P
58
47mm DISK
11

FIG 2

SYSTEM AND METHOD FOR ELECTRONICALLY RECORDING AND PLAYING BACK VIDEO IMAGES WITH IMPROVED CHROMINANCE CHARACTERISTICS USING ALTERNATE EVEN AND ODD CHROMINANCE SIGNAL LINE MATRIX ENCODING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to an apparatus and method for electronically recording and playing back video images and, more particularly, to an apparatus and method for encoding and recording electronic image information signals in a manner whereby vertical chrominance resolution may be substantially increased upon playback of the coded video signals.

2. Description of the Prior Art

Electronic imaging cameras for recording still images are now well known in the art. Such cameras can record a plurality of still images on a single magnetic disk or tape in either analog or digital format for subsequent playback on any well-known cathode ray tube viewing device or for subsequent recording a hard copy by any one of a variety of copiers such as photographic, thermal, ink jet, etc. Recently, the Japanese have standardized the magnetic disk in which the still images are recorded to a 47 mm floppy disk. In the 47 mm video floppy disk format, each frame of the image is stored as two interlaced fields of odd and even field lines. Luminance information (Y) is stored for every line while each of two chrominance components (R-Y) and (B-Y), i.e., red minus luminance and blue minus luminance, is stored in every other line of every field as shown in Table No. 1 below.

TABLE NO. 1

Frame Line No.	Stored Information	
	Field 1	Field 2
1	Y_1, $R_1 - Y_1$	
2		Y_2, $R_2 - Y_2$
3	Y_3, $B_3 - Y_3$	
4		Y_4, $B_4 - Y_4$
5	Y_5, $R_5 - Y_5$	
6		Y_6, $R_6 - Y_6$

As is readily apparent, each chrominance component (R-Y) and (B-Y) is sampled on two adjacent lines of the full frame image and then not sampled for the next two lines and so on. That offset sampling pattern provides lower vertical chrominance resolution than if each color component were sampled on every other line. The desired every other line color sampling is shown below in Table No. 2.

TABLE NO. 2

Frame Line No.	Sample
1	$R_1 - Y_1$
2	$B_2 - Y_2$
3	$R_3 - Y_3$
4	$B_4 - Y_4$
5	$R_5 - Y_5$
6	$B_6 - Y_6$

For a standard interlaced system, the sampling pattern of Table No. 2 would cause each field to contain samples of only one chrominance component so that the odd numbered frame lines (odd field) would contain only R-Y information and the even numbered frame lines (even field) would contain only B-Y information which would be incompatible with the 47 mm video floppy standard.

Therefore, it is a primary object of this invention to provide an apparatus and method in which video image data may be sampled in the manner of Table No. 2 to provide increased vertical chrominance resolution and thereafter coded in a manner that is compatible for recording on the standard 47 mm floppy disk.

It is a further object of this invention to provide an apparatus and method for playing back information recorded in the manner of this invention to enable the reconstruction of images having improved vertical chrominance resolution.

Other objects of the invention will be, in part, obvious and will, in part, appear hereinafter. The invention accordingly comprises a mechanism and system possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure.

SUMMARY OF THE INVENTION

A system for encoding and recording a video signal comprises means for sensing at least three different colors of light from a subject along a plurality of succeeding substantially parallel lines over a two-dimensional light sensing area and for providing an electronic information color component signal for each of the light colors so sensed. Means thereafter operate to provide: a luminance signal as a function of a select matrix of the color component signals for each of the substantially parallel lines; a first chrominance signal as a function of the select matrix of the color component signals for every odd line of the substantially parallel lines; and a second chrominance signal as a function of the select matrix of the color component signals for every even line of the substantially parallel lines. Means are also provided for recording luminance signals for every one of the odd lines of the substantially parallel lines in a manner whereby the luminance signals for every one of the odd lines are recorded in alternate association respectively with the first and second chrominance signals for first select alternate odd lines and alternate even lines. Means also operate to record the luminance signal for every one of the even lines of the substantially parallel lines in a manner whereby the luminance signals for the even lines are recorded in alternate association respectively with the first and second chrominance signals for second select alternate odd lines and alternate even lines.

A system is provided for decoding the video image information recorded in both even and odd field lines on a recording medium where the luminance information is recorded for both the even and odd field lines, first chrominance information is recorded for the odd field lines and second chrominance information is recorded for the even field lines. The system provides means for converting the recorded luminance information to electronic luminance signals in a select order of field lines whereby all of either the even or odd field lines are first converted and then all of the remaining even or odd field lines are thereafter converted. Means are provided for converting: the first chrominance information to first electronic chrominance signals in concert with the conversion of the luminance signals for the odd field lines, the second chrominance information to second electronic chrominance signals in concert with the conversion of the luminance signals for the even field lines,

the second chrominance information to the second chrominance signals and thereafter interpolating the second chrominance signals for odd field lines in concert with the conversion of the luminance information for the odd field lines; and the first chrominance information to the first chrominance signals and thereafter interpolating the first chrominance signals for even field lines in concert with the conversion of the luminance information for the even field lines. Means are provided for matrixing: the luminance signals for the odd and even field lines; the first and second chrominance signals and the interpolated chrominance signals for the odd and even lines to provide electronic information color component signals from which a visible image of the recorded information may be made.

DESCRIPTION OF THE DRAWINGS

The novel features that are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with other objects and advantages thereof will be best understood from the following description of the illustrated embodiment when read in connection with the accompanying drawings wherein:

FIG. 1 is a schematic circuit diagram for the system of this invention for encoding and recording a video signal; and

FIG. 2 is a circuit diagram for the system of this invention for decoding a video signal recorded by the system of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown a circuit diagram for the system of this invention for encoding and recording a video signal. Scene light from a subject to be recorded is directed in a well-known manner by way of an objective lens and shutter (both not shown) to be incident upon the surface of a two-dimensional image light sensing array **12** which may be a charge-coupled device (CCD), a charge-injection device (CID), a photodiode array or any other conventional photosensitive array. The light sensing array **12** comprises a predetermined number of discrete image sensing areas or pixels **13** arranged in vertical columns and horizontal frame lines **1–6** wherein each column is superposed by either a cyan, green or yellow colored filter arranged in a well-known manner as shown in the drawing. Although cyan, green and yellow filters are shown by way of example, it will be well understood that other color filter combinations could also be utilized such as the primary red, green and blue colors as is also well known in the art. In addition, it will be well understood that although the image sensing array **12** is illustrated as comprising only 36 image sensing areas or pixels **13** arranged in 6 horizontal field lines, that in reality such image sensing arrays preferably comprise many thousands of such pixels **13** arranged in hundreds of horizontal frame lines.

Electronic information signals corresponding to the subject colors sensed are transferred from the image sensing array **12** in serial fashion by a serial shift register **14** as is well known in the art. The serial shift register **14** operates to provide a continuous stream of cyan, green and yellow analog color component signals from each succeeding line (**1–6**) of the light sensing elements **13** in the two-dimensional array **12** as shown below:


```
Line 6        Line 2    Line 1
          ...
CGYCGY        CGYCGY    CGYCGY
```

In this manner, means are provided for sensing at least three different colors of light, i.e., cyan, green and yellow, from a subject along a plurality of succeeding substantially parallel lines (**1–6**) over the two-dimensional light sensing array **12** and for providing an electronic information color component signal for each of the light colors so sensed. The electronic information color component signal from the serial shift register **14**, in turn, is directed by way of a preamplifier **16** and amplifier **18** for conversion from an analog format to a digital format by an analog-to-digital converter **20**. The digitally formatted color component output signals from the analog-to-digital converter **20** are thereafter stored in a random access memory (RAM) **22** for a limited time interval. The digitally formatted color component signals stored in the random access memory **22** are thereafter reformatted back to an analog signal by way of a digital-to-analog converter **24**.

The analog formatted color component signals from the digital-to-analog converter **24** are thereafter directed to a multiplexer **26** wherein the color component signals for the odd field lines (**1, 3** and **5**) of the image sensing array **12** are separated from the color component signals for the even field lines (**2, 4** and **6**) of the image sensing array **12**. The odd field line color component signals are directed to a delay line **28** wherein the signals are delayed by one line interval so that the color component signals for each odd field line arrive at a demultiplexer **30** in synchronism with the arrival of the color component signals for each even field line at a demultiplexer **32**. In this manner the delay circuit **28** operates to substantially eliminate any phase difference between the color component signals from the odd and even field lines. The demultiplexer circuits **30** and **32** operate, in turn, to demultiplex the yellow, green and cyan color component signals, respectively, to provide output color component signals as shown below:

```
Line 6            Line 2          Line 1

C _ _ C _ _       C _ _ C _ _     C _ _ C _ _
_ G _ _ G _  ...  _ G _ _ G _     _ G _ _ G _
_ _ Y _ _ Y       _ _ Y _ _ Y     _ _ Y _ _ Y
```

Thus, it can be seen that each pixel of the light sensing array **12** is identified by only one color component signal and that the other two color component signals must be interpolated for each pixel in order for each pixel to be identified by the three yellow, green and cyan color component signals. Toward this end, sample and hold circuits **34, 36, 38, 40, 42** and **44** are provided to sample and hold each color component signal for both the odd and even field lines respectively to provide two interpolated color component signals for each pixel of the image sensing array **12** thereby providing the output color component signals as illustrated below.

```
Line 6         Line 2     Line 1

CCCCCC   ...   CCCCCC     CCCCCC
GGGGGG         GGGGGG     GGGGGG
YYYYYY         YYYYYY     YYYYYY
```

The cyan, green and yellow color component signals from the sample and hold circuits **34**, **36** and **38** are directed to a color matrix circuit **46** for conversion to a luminance signal (Y) at output terminal A and a first chrominance signal (R-Y) at output terminal B for the odd field lines. In like manner, the yellow, green and cyan color component signals from the sample and hold circuits **40**, **42** and **44** are directed respectively for conversion by a color matrix circuit **48** to a luminance signal (Y) at output terminal C and a second chrominance signal (B-Y) at output terminal D for the even field lines. As is well understood, B in the first chrominance signal (B-Y) represents the color blue and R in the second chrominance signal (R-Y) represents the color red. The color matrix equations for the matrix circuits **46** and **48** are derived in the following manner. Yellow, green and cyan color component signals can be matrixed to provide red, green and blue color component signals in accordance with the following matrix equation:

$$\begin{matrix} R \\ G \\ B \end{matrix} = \begin{bmatrix} 2 & -1 & 0 \\ 0 & 1 & 0 \\ 0 & -1 & 2 \end{bmatrix} \begin{matrix} Ye \\ G \\ C \end{matrix}$$

The red, green and blue color components can, in turn, be matrixed to provide the luminance signal (Y), the first chrominance signal (R-Y) and the second chrominance signal (B-Y) in accordance with the following matrix equation:

$$\begin{matrix} Y \\ R-Y \\ B-Y \end{matrix} = \begin{bmatrix} .299 & .587 & .114 \\ .701 & -.587 & -.114 \\ -.299 & -.587 & .886 \end{bmatrix} \begin{matrix} R \\ G \\ B \end{matrix}$$

Combining the above matrix equations in the following manner provides the color matrix equation by which the yellow, green and cyan color component signals are matrixed to provide the luminance signal (Y), the first chrominance signal (R-Y) and the second chrominance signal (B-Y).

$$\begin{matrix} Y \\ R-Y \\ B-Y \end{matrix} = \begin{bmatrix} .299 & .587 & .114 \\ .701 & -.587 & -.114 \\ -.299 & -.587 & .886 \end{bmatrix} \begin{bmatrix} 2 & -1 & 0 \\ 0 & 1 & 0 \\ 0 & -1 & 2 \end{bmatrix} \begin{matrix} Ye \\ G \\ C \end{matrix}$$

or

$$\begin{matrix} Y \\ R-Y \\ B-Y \end{matrix} = \begin{bmatrix} .598 & 1.174 & .228 \\ 1.402 & -1.174 & -.228 \\ -.598 & -1.174 & 1.772 \end{bmatrix} \begin{matrix} Ye \\ G \\ C \end{matrix}$$

As a result of the color component signals being temporarily stored in the random access memory **22** and the effect of the delay circuit **28**, the output signals from the matrix circuits **46** and **48** at output terminals A, B, C and D are tabulated as shown in the following Table No. 3 where the subscripts reference field lines.

TABLE NO. 3

A	B	C	D
Y_1	$R_1 - Y_1$	Y_2	$B_2 - Y_2$
Y_3	$R_3 - Y_3$	Y_4	$B_4 - Y_4$
Y_5	$R_5 - Y_5$	Y_6	$B_6 - Y_6$

The luminance and chrominance output signals as tabulated above in Table No. 3 are directed to input a multiplex or switch circuit **49**. The multiplexer **49** first operates to connect the luminance signal (Y) from the output terminal A of matrix **46** to output terminal E while alternately connecting the first chrominance signal (R-Y) from output terminal B of matrix **46** and the second chrominance signal (B-Y) from output terminal D of matrix **48** to output terminal F. The luminance and chrominance signals outputted at terminals E and F respectively from the multiplex circuit **49** are tabulated in Table No. 4 as follows:

TABLE NO. 4

E	F
Y_1	$R_1 - Y_1$
Y_3	$B_4 - Y_4$
Y_5	$R_5 - Y_5$

From the above Table No. 4, it is apparent that the luminance signals for the odd field lines appear in alternate association respectively with the first and second chrominance signals for first select alternate odd field lines and alternate even field lines. The first select alternate odd field lines for which the first chrominance signals are provided are lines **1** and **5**, but would include lines **9**, **13**, **17**, etc. for light sensing arrays having substantially more field lines, while the first select alternate even field lines for which the second chrominance signals are provided include only line **4** for the example shown, but would include lines **8**, **12**, **16**, etc. for light sensing arrays having substantially more field lines. The above luminance and chrominance signals of Table No. 4 are thereafter FM modulated by FM modulator circuits **52** and **50**, respectively, and subsequently amplified by a drive amplifier **54** for recording by a recording head **56** on a first track of a magnetic recording disk **58** which preferably conforms to the afore-mentioned 47 mm floppy disk format. Thus, in this manner, the luminance signals for every one of the odd field lines is recorded in alternate association respectively with the first select alternate odd field lines of the first chrominance signal and the first select alternate even field lines of the second chrominance signal.

After the luminance and chrominance signals are recorded in the above manner for the odd field lines, the multiplexer circuit **49** then operates to connect the luminance output signal (Y) from the output terminal C of the matrix circuit **48** to the output terminal E of the multiplex circuit **49** while alternately connecting the first chrominance signal (R-Y) from the output terminal B of matrix **46** and the second chrominance signal (B-Y) from the output terminal D of matrix **48** to the output terminal F. The luminance and chrominance signals appear at the output terminals E and F respectively as tabulated below in Table No. 5:

TABLE NO. 5

E	F
Y_2	$B_2 - Y_2$
Y_4	$R_3 - Y_3$

TABLE NO. 5-continued

E	F
Y_6	$B_6 - Y_6$

From the above tabulated data of Table No. 5, it can be seen that the luminance signals for every one of the even field lines is provided in alternate association respectively with the first and second chrominance signals for second select alternate odd and alternate even field lines. The second select alternate odd field lines can be seen to include only line **3**, but would include lines **7**, **11**, **15**, etc. for light sensing arrays having substantially more field lines, while the second select alternate even lines are **2** and **6**, but would include lines **10**, **14**, **18**, etc. for light sensing arrays having substantially more field lines. The luminance signals for the even field lines at output terminal E and the first and second chrominance signals for the second select alternate odd and alternate even field lines at output terminal F are subsequently FM modulated by FM modulator circuits **52** and **50**, respectively and thereafter amplified by the drive amplifier **54** for recording on a second track of the magnetic disk **58** by the recording head **56**. Thus, in this manner the luminance signals for all the even field lines are recorded in alternate association respectively with the second select alternate even field lines of the second chrominance signal and second select alternate odd field lines of the first chrominance signal. As will be well understood, a central processing unit (CPU) or controller (not shown) operates to control the sequence in which electronic information signals are transmitted between the various components in the manner as previously described.

Referring now to FIG. **2**, there is shown at **11** the circuit of this invention for decoding the electronic image information stored on the disk **58** in the aforementioned manner. The electronic image information stored on the disk **58** is read by a playback head **60** to provide electronic information signals that are subsequently amplified by a preamplifier **62** and thereafter demodulated by FM demodulators **64** and **66** to provide respectively luminance signals and chrominance signals. Playback begins with the recording head first reading the first and second chrominance signals for the second select alternate odd field lines and alternate even field lines recorded on the second track in association with the luminance signals for the even field lines. The first and second chrominance signals for the second select alternate odd field lines and alternate even field lines are amplified by the amplifier **62** and FM demodulated by the demodulator **66** prior to conversion from an analog format to a digital format by an analog-to-digital converter **68**. The digitally formatted chrominance signals are thereafter stored for a determinate time interval in a random access memory (RAM) **70**.

The playback head **60** thereafter reads the luminance signals for the odd field lines recorded on the first track of the disk **58** together with its associated chrominance signals for the first select alternate odd field lines and alternate even field lines. The chrominance signals for the first select alternate odd field lines and alternate even field lines are demodulated by the FM demodulator **66** while the associated luminance signals for the odd field lines are FM demodulated by the FM demodulator **64**. At the same time that the chrominance signals for the second select alternate odd field lines and alternate even field lines are read out from the RAM **70**, the chrominance signals for the first select alternate odd field lines and alternate even field lines are played back from the disk **58** and stored in the random access memory **70**. The chrominance signals for the second select alternate even field lines and alternate odd field lines are converted from the digital format to an analog format by way of the digital-to-analog converter **72**. Line delay circuits **74** and **78** operate to delay the chrominance signals in a manner so as to provide the output signals at lines A, B, C, D and E as tabulated below in Table No. 6:

TABLE NO. 6

A	B	C	D	E
Y_1	—	$B_2 - Y_2$	—	$R_1 - Y_1$
Y_3	$B_2 - Y_2$	$R_3 - Y_3$	$R_1 - Y_1$	$B_4 - Y_4$
Y_5	$R_3 - Y_3$	$B_6 - Y_6$	$B_4 - Y_4$	$R_5 - Y_5$

As is readily apparent from the above Table No. 6 tabulation, it can be seen that line delay circuits **74** and **78** operate to delay the chrominance signals on lines D and B respectively by one field line. From the above Table No. 6, it is readily apparent that the first chrominance signal (R-Y) for each odd field line is present at the same instant that the luminance signal (Y) for each odd field line appears and that the second chrominance signal (B-Y) is also present for each adjacent even field line thereby enabling an interpolated value for the second chrominance signal to be calculated for each odd field line. For instance, it can be seen that the luminance signal (Y_1) for the first field line appears at line A simultaneously with the first chrominance signal (R_1-Y_1) on line E together with the adjacent second chrominance signal (B_2-Y_2). In like manner, the luminance signal (Y_3) for the third field line is provided simultaneously with the first chrominance signal (R_3-Y_3) on line C together with the adjacent second chrominance signals (B_2-Y_2) on line B and (B_4-Y_4) on line E which are averaged together by the averaging circuit **82** to provide an average second chrominance signal for the third field line. A multiplex or switch circuit **80** operates to provide the output chrominance signals on lines F, G and I as tabulated below in Table No. 7:

TABLE NO. 7

F	G	I	H
—	—	$R_1 - Y_1$	—
$B_2 - Y_2$	$B_4 - Y_4$	$R_3 - Y_3$	$[(B_2 - Y_2) + (B_4 - Y_4)]/2$
$B_4 - Y_4$	$B_6 - Y_6$	$R_5 - Y_5$	$[(B_4 - Y_4) + (B_6 - Y_6)]/2$

An averaging circuit **82** thereafter operates to add the chrominance signals (B-Y) from lines F and G and divide the result by two to provide an output average value on line H as shown in the above Table No. 7 for the chrominance signals which in this instance are the average second chrominance signals for the even field lines. The output signals are transmitted by a multiplex or switch circuit **84** to provide the first chrominance signals (R-Y) on line K for each set of odd field lines simultaneously with first interpolated chrominance signals (B-Y) on line L as a function of the average of the second chrominance signals for adjacent even field lines.

With switch S_1 moved to the solid line position to bypass line delay circuit **88**, the luminance signal Y on line J, the first chrominance signal (R-Y) on line K, and the interpolated second chrominance signal (B-Y) on line L are thereafter converted to well-known red,

green and blue color component signals by matrix circuit **86** operating in a well-known manner. The red, green and blue color component signals may thereafter be utilized in a well-known manner to provide a visible image of the subject on either the screen of a CRT or by way of any conventional hard copy printer such as photographic, thermal, ink jet, etc. The output red, green and blue color component signals may be derived from the luminance (Y) signals and the chrominance signals (R-Y), (B-Y) by the following matrix equation:

$$\begin{matrix} R \\ G = \\ B \end{matrix} \begin{bmatrix} 1 & 1 & 0 \\ 1 & -0.509 & -0.194 \\ 1 & 0 & 1 \end{bmatrix} \begin{matrix} Y \\ R-Y \\ B-Y \end{matrix}$$

After the odd field lines are decoded and reconstructed in the aforementioned manner, the playback head is moved to the second track of the recording disk **58** to read out the image data recorded for the even field lines. As previously discussed, the chrominance signals for the first select alternate odd field lines and alternate even field lines were stored in the random access memory (RAM) **70** and replaced the chrominance signals for the second select alternate odd field lines and alternate even field lines which were read out to derive the color component signals for the odd field lines. The switch S_1 is moved to its phantom line position so as to delay the luminance signal on line A by one field line. In a manner analogous to the above-described playback operation, the luminance signals for the even field lines and the associated chrominance signals for the second select alternate odd field lines and alternate even field lines are played back at the same time that the chrominance signals for the first select alternate odd field lines and alternate even field lines are read out from the random access memory **70** and converted to an analog format by the digital-to-analog converter **72** so as to cause the signals to appear at lines J, B, C, D and E as tabulated below in Table No. 8:

TABLE NO. 8

J	B	C	D	E
—	—	$R_1 - Y_1$	—	$B_2 - Y_2$
Y_2	$R_1 - Y_1$	$B_4 - Y_4$	$B_2 - Y_2$	$R_3 - Y_3$
Y_4	$B_4 - Y_4$	$R_5 - Y_5$	$R_3 - Y_3$	$B_6 - Y_6$
Y_6	$R_5 - Y_5$	$B_8 - Y_8$	$B_6 - Y_6$	$R_7 - Y_7$

Thus, from the signals tabulated above in Table No. 8, it can be seen that all the luminance and chrominance signals appear simultaneously for each field line in order to recreate the entire even line field. For instance, it can be seen that the luminance signal (Y_2) for the second field line appears at line J simultaneously with the second chrominance signal (B_2-Y_2) on line D together with adjacent first chrominance signals (R_1-Y_1) on line B and (R_3-Y_3) on line E which may be averaged together by averaging gate **82** in the aforementioned manner to provide an average first chrominance signal value for the second field line. In like manner, the luminance signal Y_4 for the fourth field line is provided simultaneously with the second chrominance signal (B_4-Y_4) on line B together with the first chrominance signal (R_5-Y_5) on line C and (R_3-Y_3) on line D which are averaged together by the averaging circuit **82** to provide an average first chrominance signal for the fourth field line. As is readily apparent, the above-described operation continues on the remaining even field lines to provide the output chrominance signals on lines F, G, I, and H as tabulated below in Table No. 9:

TABLE NO. 9

F	G	I	H
$R_1 - Y_1$	$R_3 - Y_3$	$B_2 - Y_2$	$[(R_1 - Y_1) + (R_3 - Y_3)]/2$
$R_3 - Y_3$	$R_5 - Y_5$	$B_4 - Y_4$	$[(R_3 - Y_3) + (R_5 - Y_5)]/2$
$R_5 - Y_5$	$R_7 - Y_7$	$B_6 - Y_6$	$[(R_5 - Y_5) + (R_7 - Y_7)]/2$

The average first chrominance signals on line H and the second chrominance signals on line I are thereafter transmitted by the multiplexing circuit **84** to provide average first chrominance signals (R-Y) on line K together with second chrominance signals (B-Y) on line L. The luminance signals Y on line J are thereafter matrixed with the first and second chrominance signals by the matrix circuit **86** to provide the red, green and blue color component signals as previously described. The color component signals may thereafter be utilized in a conventional manner to reconstruct the even line field of the subject image either in a CRT display screen or as a hard copy. Thus, there can be provided an image with as much as twice the vertical chrominance resolution of an image conventionally provided from a 47 mm video floppy player since the chrominance samples of this invention are spaced only two field lines apart in contrast to a conventional player which interpolates between chrominance lines independently for each field resulting in an image with chrominance samples effectively spaced four field lines apart. The technique of this invention is applicable to any conventional video format where alternate color components are stored on each field line such as PAL and may be used with any CCD regardless of whether the color filters are arranged in vertical stripes as previously described or in any other mosaic filter pattern as is well known in the art.

Luminance and chrominance signals recorded in the manner as shown in Tables 4 and 5 could not be decoded by conventional playback devices. However, by delaying the second chrominance signals (R-Y) by one field line, the luminance and chrominance signals can be outputted at terminals E and F respectively as tabulated in the following tables 10 and 11 where the light sensing array **12** includes at least seven (7) horizontal lines:

TABLE NO. 10

E	F
Y_1	$R_1 - Y_1$
Y_3	$B_2 - Y_2$
Y_5	$R_5 - Y_5$

TABLE NO. 11

E	F
Y_2	$R_3 - Y_3$
Y_4	$B_4 - Y_4$
Y_6	$R_7 - Y_7$

The sequence in which electronic signals are transmitted by the decoding circuit **11** may be conventionally modified to enable the circuit **11** to decode the luminance and chrominance signals tabulated in Tables 10 and 11 as well as luminance and chrominance signals recorded in a standard format. The recording disk **58** on which luminance and chrominance signals are recorded as shown in Tables 10 and 11 may also be played back on a conventional playback device as well as the decod-

ing circuit 11 of this invention. However, luminance and chrominance signals recorded in the manner of this invention and played back on a conventional playback device will not have the high vertical chrominance resolution achievable with the decoder 11 of this invention. In addition, luminance and chrominance signals recorded in a standard format and played back with the decoder 11 of this invention will also not have the high vertical chrominance resolution achievable by recording the luminance and chrominance signals in the manner of this invention.

Other changes may be made in the above-described embodiment without departing from the scope of the invention herein involved, therefore it is intended that all matter contained in the above description or shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A system for encoding and recording a video signal comprising:

means for sensing at least three different colors of light from a subject along a plurality of succeeding substantially parallel lines over a two-dimensional light sensing area and providing an electronic information color component signal for each of the light colors so sensed;

means for providing: a luminance signal as a function of a select matrix of said color component signals for each of said substantially parallel lines; a first chrominance signal as a function of said select matrix of said color component signals for every odd line of said substantially parallel lines; and a second chrominance signal as a function of said select matrix of said color component signals for every even line of said substantially parallel lines;

means for combining said luminance signal for every one of said odd lines of said substantially parallel lines in a manner whereby said luminance signals for every one of said odd lines are combined in alternate association respectively with first select alternate odd lines of said first chrominance signal and first select alternate even lines of said second chrominance signal and for combining said luminance signal for every one of said even lines of said substantially parallel lines in a manner whereby said luminance signals for said even lines are combined in alternate association respectively with second select alternate even lines of said second chrominance signal and second select alternate even lines of said first chrominance signal; and

means for recording said combined signals.

2. The system of claim 1 for use with a recording media of the type on which information can be recorded on two spaced apart tracks wherein said recording means operates to record said combined signal which includes luminance signals for odd lines on a first track of the recording media and to record said combined signal which includes luminance signals for even lines on a second track of the recording media.

3. The system of claim 2 wherein said means for providing said luminance and chrominance signals comprises: means for separating said color component signals to provide at a first output terminal the color component signals for said odd lines and at a second output terminal the color component signals for said even lines, first means for matrixing the color component signals for said odd lines to provide the luminance signals for said odd lines and said first chrominance signals for said even lines to provide the luminance signals for said even lines and said second chrominance signals.

4. The system of claim 3 wherein said separating means comprises means for multiplexing said color component signals and said means for providing said luminance and chrominance signals comprise means for delaying the color component signals from either one of said first and second output terminals from said multiplexer for a time period substantially equal to the phase difference between the color component signals from said first and second output terminals, and means for demultiplexing the color component signals from said delay means and the other one of said first and second output terminals prior to matrixing by said first and second matrix means.

5. The system of claim 4 including means for sampling and holding each color component signal received from said demultiplexing means for interpolating portions thereof not sensed by sensing means prior to matrixing by said first and second matrix means.

6. The system of claim 3 wherein said recording means comprises means for multiplexing the luminance and chrominance signals from said first and second matrixing means in a manner whereby the luminance signals output from said first matrix means are continuously transmitted for recording while the first chrominance signals output from said first matrix means and the second chrominance signals output from said second matrix means for said first select alternate odd and alternate even lines are alternately transmitted for recording on the first track of the recording media and the luminance signals output from said second matrix means are thereafter continuously transmitted for recording while the first chrominance signal output from said first matrix means and the second chrominance signal output from said second matrix means for said second select alternate odd lines and alternate even lines are alternately transmitted for recording on the second track of the recording media.

7. The system of claim 1 wherein said means for providing said luminance and chrominance signals comprises an analog-to-digital converter for converting the electronic information color component signals received from said light sensing means from an analog to a digital format, buffer memory means for storing the electronic information color component signals received from said analog-to-digital converter, and a digital-to-analog converter for converting the electronic information color component signals received from said buffer memory means from their digital format back to an analog format.

8. The system of claim 1 wherein said three different colors of light sensed from the subject by said light sensing means are cyan, green, and yellow and said luminance, first chrominance and second chrominance signals are provided as a function of said select matrix of said cyan, green and yellow color component signals in accordance with the equations: luminance=0.598(yellow)+1.174(green)+0.228(cyan), first chrominance=1.402(yellow)−1.174(green)−0.228(cyan), second chrominance=0.598(yellow)−1.174(green)+1.772(cyan).

9. A system for decoding video image information recorded in both even and odd field lines on a recording medium wherein luminance information is recorded for both the even and odd field lines, first chrominance information is recorded for the odd field lines and sec-

ond chrominance information is recorded for the even field lines, comprising:

means for converting the recorded luminance information to electronic luminance signals in a select order of field lines whereby all of either the even or odd field lines are first converted and then all of the remaining odd or even field lines are thereafter converted;

means for converting: the first chrominance information to first electronic chrominance signals in synchronism with the conversion of said luminance signals for odd field lines, the second chrominance information to second electronic chrominance signals in synchronism with the conversion of said luminance signals for said even field lines, and thereafter interpolating odd field lines from said second chrominance signals in synchronism with the conversion of said luminance information for said odd field lines, and the first chrominance information to said first chrominance signals and thereafter interpolating even field lines from said first chrominance signals in synchronism with the conversion of said luminance information for said even field lines and the second chrominance information to said second chrominance signals, and

means for matrixing: said luminance signals for said odd and even field lines, said first and second chrominance signals, and said interpolated chrominance signals for said odd and even field lines to provide electronic information color component signals from which a visible image of the recorded information may be made.

10. A system for decoding video image information recorded in both even and odd field lines on a recording medium wherein luminance information is recorded for both the even and odd field lines, first chrominance information is recorded for the odd field lines and second chrominance information is recorded for the even field lines, comprising:

means for converting the recorded luminance information to electronic luminance signals in a select order of field lines whereby all of either the even or odd field lines are first converted and then all of the remaining odd or even field lines are thereafter converted;

means for converting: the first chrominance information to first electronic chrominance signals in synchronization with the conversion of said luminance signals for said odd field lines, the second chrominance information to second electronic chrominance signals in synchronization with the conversion of said luminance signals for said even field lines, and thereafter interpolating odd field lines from said second chrominance signals in synchronization with the conversion of said luminance information for said odd field lines, and the first chrominance information to said first chrominance signals and thereafter interpolating even field lines from said first chrominance signals in synchronization with the conversion of said luminance information for said even field lines and the second chrominance information to said second chrominance signals, and

means for matrixing: said luminance signals for said odd and even field lines, said first and second chrominance signals, and said interpolated chrominance signals for said odd and even field lines to provide electronic information color component signals from which a visible image of the recorded information may be made, said system being for use with a recording media of the type on which information is recorded on two spaced apart tracks, the first track of which has luminance information for the odd field lines and first and second chrominance information for first select alternate odd field lines and alternate even field lines respectively recorded thereon and the second track of which has luminance information for the even field lines and second and first chrominance information for second select alternate even field lines and alternate odd field lines respectively recorded thereon, wherein said converting means includes a memory for storing and means for synchronously providing said first and second chrominance signals for said first select alternate odd field lines and alternate even field lines for storage by said memory and said luminance information for said even field lines and said second and first chrominance information for said second select alternate even field lines and alternate odd field lines for conversion by said converting means and alternatively for for synchronously providing said second and first chrominance signals for said second select alternate even field lines and alternate odd field lines for storage by said memory and said luminance information for said odd field lines and said first and second chrominance information for said first select alternate odd field lines and alternate even field lines for conversion by said converting means.

11. The system of claim 10 wherein said converting means comprises a multiplexing and delay means for receiving said first and second chrominance signals for said first select alternate odd field lines and alternate even field lines from said memory and said first and second chrominance signals for said second select alternate odd field lines and alternate even field lines to provide said second chrominance signals for each of said even field lines simultaneously with said first chrominance signal for each adjacent odd field line and alternatively for receiving said first and second chrominance signals for said second select alternate odd field lines and alternate even field lines from said memory and said first and second chrominance signals for said first select alternate odd field lines and alternate even field lines to provide said first chrominance signals for each of said odd field lines simultaneously with said second chrominance signals for each adjacent even field line and averaging means for providing first interpolated chrominance signals for each even field line as a function of the average of said first chrominance signals for said adjacent odd field lines and for providing second interpolated chrominance signals for each odd field line as a function of the average of said second chrominance signals for said adjacent even field lines.

12. The system of claim 11 wherein said converting means further includes a first frequency demodulator for demodulating said luminance signals for said odd and even field lines, means for selectively delaying the luminance signals for one field line, and a second frequency demodulator for demodulating said first and second chrominance signals.

13. The system of claim 10 wherein: said converting means comprises an analog-to-digital converter for converting said first and second chrominance signals from an analog to a digital format; said memory stores said first and second chrominance signals received from said

analog-to-digital converter; and said converting means further comprises a digital-to-analog converter for converting said first and second chrominance signals received from said memory from a digital format back to an analog format.

14. A system for decoding video image information recorded in both even and odd field lines on a recording medium wherein luminance information is recorded for both the even and odd field lines, first chrominance information is recorded for the odd field lines and second chrominance information is recorded for the even field lines, comprising:

means for converting the recorded luminance information to electronic luminance signals in a select order of field lines whereby all of either the even or odd field lines are first converted and then all of the remaining odd or even field lines are thereafter converted;

means for converting: the first chrominance information to first electronic chrominance signals in synchronization with the conversion of said luminance signals for said odd field lines, the second chrominance information to second electronic chrominance signals in synchronization with the conversion of said luminance signals for said even field lines, and thereafter interpolating odd field lines from said second chrominance signals in synchronization with the conversion of said luminance information for said odd field lines, and the first chrominance information to said first chrominance signals and thereafter interpolating even field lines from said first chrominance signals in synchronization with the conversion of said luminance information for said even field lines and the second chrominance information to said second chrominance signals, and

means for matrixing: said luminance signals for said odd and even field lines, said first and second chrominance signals, and said interpolated chrominance signals for said odd and even field lines to provide electronic information color component signals from which a visible image of the recorded information may be made, wherein said color component signals are respectively red, green and blue color component signals and are provided as a function of a select matrix of said luminance and said first and second chrominance signals including said interpolated chrominance signals in accordance with the equations:

red=luminance+first chrominance, green=luminance−0.509(first chrominance)−0.194 (second chrominance), blue=luminance+second chrominance.

15. A method for sampling, encoding and recording a video signal comprising the steps of:

sensing at least three different colors of light from a subject along a plurality of succeeding substantially parallel lines over a two-dimensional light sensing area;

matrixing said color component signals for each of said substantially parallel lines to provide: a luminance signal; a first chrominance signal for every odd line of said substantially parallel lines, and a second chrominance signal for every even line of said substantially parallel lines;

combining said luminance signal for every one of said odd lines of said substantially parallel lines in a manner whereby said luminance signals for said odd lines are combined in alternate association respectively with first select alternate odd lines of said first chrominance signal and first select alternate even lines of said second chrominance signal;

combining said luminance signal for every one of said even lines of said substantially parallel lines in a manner whereby said luminance signals for said even lines are combined in alternate association respectively with second select alternate even lines of said second chrominance signal and second select alternate odd lines of said first chrominance signal; and

recording the combined signals.

16. The method of claim 15 wherein:

the recording media is of the type on which information can be recorded on two spaced apart tracks, and including recording the combined signals which include the luminance signals for odd lines on a first track of the recording media and recording the combined signals which include the luminance signals for even lines on a second track of the recording media.

17. The method of claim 16 further including the step of separating the color component signals for said odd and even lines wherein said step for matrixing said color component signals comprises the steps of matrixing the color component signals for said odd lines to provide the luminance signals for said odd lines and said first chrominance signals and matrixing the color component signals for said even lines to provide the luminance signals for said even lines and said second chrominance signals.

18. The method of claim 17 wherein the color component signals are separated for said odd and even lines by multiplexing and further comprising the step of delaying the color component signal for either said odd or even lines for a time substantially equal to the phase difference between the color component signals for said odd and even lines and demultiplexing the color component signals prior to matrixing.

19. The method of claim 18 further comprising the steps of sampling and holding each demultiplexed color component signal and interpolating portions thereof not previously sensed prior to matrixing.

20. The method of claim 16 further comprising the steps of multiplexing the matrixed luminance and chrominance signals in a manner so that the matrixed luminance signals for the odd lines are transmitted for recording at the same time that the matrixed first and second chrominance signals for said first select alternate odd lines and alternate even lines are alternately transmitted for recording on the first track of the recording media and so that the matrixed luminance signals for the even lines are transmitted for recording at the same time that the matrixed first and second chrominance signals for said second select alternate odd lines and alternate even lines are alternately transmitted for recording on the second track of the recording media.

21. The method of claim 15 further comprising the step of converting the sensed electronic information color component signals from an analog-to-digital format, storing the digitally formatted electronic information color component signals for a determinate time, and after said determinate time converting the electronic information color component signal back to an analog format.

22. The method of claim 15 wherein said light sensing step comprises sensing light through cyan, green and yellow filters and said step of matrixing said cyan,

green, and yellow color component signals to provide said luminance, first chrominance and second chrominance signals is in accordance with the equations: luminance=0.598(yellow)+1.174(green)+0.228(cyan), first chrominance=1.402(yellow)−1.174(green)−0.228(cyan), second chrominance=−0.598(yellow)−1.174(green)+1.772(cyan).

23. A method for decoding video image information recorded in both even and odd field lines on a recording medium wherein luminance information is recorded for both the even and odd field lines, first chrominance information is recorded for the odd field lines, and second chrominance information is recorded for the even field lines comprising the steps of:

converting: the recorded luminance information to electronic luminance signals in a select order of field lines including converting all of either the even or odd field lines and then converting all of the remaining odd or even field lines; the first chrominance information to first electronic chrominance signals in synchronism with the conversion of said luminance signals for said odd field lines; the second chrominance information to second chrominance signals in synchronism with the conversion of said luminance signals for said even field lines; the second chrominance information to said second chrominance signals and thereafter interpolating odd field lines from said second chrominance signals in synchronism with the conversion of said luminance information for said odd field lines; and, said first chrominance information to said first chrominance signals and thereafter interpolating even field lines from said first chrominance signals in synchronism with the conversion of said luminance information for said even field lines; and

matrixing said luminance signals for said odd and even field lines, said first and second chrominance signals and said interpolated chrominance signals for said odd and even lines to provide electronic information color component signals from which a visible image of the recorded information may be made.

24. A method for decoding video image information recorded in both even and odd field lines on a recording medium wherein luminance information is recorded for both the even and odd field lines, first chrominance information is recorded for the odd field lines, and second chrominance information is recorded for the even field lines comprising the steps of:

converting: the recorded luminance information to electronic luminance signals in a select order of field lines including converting all of either the even or odd field lines and then converting all of the remaining odd or even field lines; the first chrominance information to first electronic chrominance signals in synchronism with the conversion of said luminance signals for saids odd field lines; the second chrominance information to second chrominance signals in synchronism with the conversion of said luminance signals for said even field lines; the second chrominance information to said second chrominance signals and thereafter interpolating odd field lines from said second chrominance signals in synchronism with the conversion of said luminance information for said odd field lines; and, said first chrominance information to said first chrominance signals and thereafter interpolating even field lines from said first chrominance signals in synchronism with the conversion of said luminance information for said even field lines; and

matrixing said luminance signals for said odd and even field lines, said first and second chrominance signals and said interpolated chrominance signals for said odd and even lines to provide electronic information color component signals from which a visible image of the recorded information may be made wherein the recording media is of the type on which information is recorded on two spaced apart tracks, the first track of which has luminance information for the odd field lines and first and second chrominance information for first select alternate odd field lines and alternate even field lines respectively recorded thereon and the second track of which has luminance information for the even field lines and second and first chrominance information for second select alternate even field lines and alternate odd field lines respectively recorded thereon, said method further comprising the steps of storing said first and second chrominance signals for said first select alternate odd field lines and alternate even field lines while converting said luminance information for said even field lines and said second and first chrominance information for said second select alternate even field lines and alternate odd field lines to luminance signals and second and first chrominance signals respectively and storing said second and first chrominance signals for said second select alternate even field lines and alternate odd field lines while converting said luminance information for said odd field lines and said first and second chrominance information for said first select alternate odd field lines and alternate even field lines to luminance signals and first and second chrominance signals respectively.

25. The method of claim 24 wherein said step for converting includes multiplexing the previously stored first and second chrominance signals for said first select alternate odd lines and alternate even lines and said first and second chrominance signals for said second select alternate odd field lines and alternate even field lines to provide said second chrominance signals for each of said even field lines simultaneously with said first chrominance signals for adjacent odd field lines; alternatively multiplexing the previously stored first and second chrominance signals for said second select alternate odd field lines and alternate even field lines and said first and second chrominance signals for said first select alternate odd field lines and alternate even field lines to provide said first chrominance signals for each of said odd field lines simultaneously with said second chrominance signals for adjacent even field lines; averaging said first chrominance signals for each of said adjacent odd field lines to provide first interpolated chrominance signals for each even field line; and averaging said second chrominance signals for each of said adjacent even field lines to provide second interpolated chrominance signals for each odd field line.

26. The method of claim 25 wherein said converting step further comprises the steps of frequency demodulating said luminance signals for said odd and even field lines, selectively delaying the luminance signals for one field line, and frequency demodulating said first and second chrominance signals.

27. The method of claim 24 further including the steps of converting said first and second chrominance signals from an analog to a digital format, storing said

digitally formatted first and second chrominance signals for a determinate time, and thereafter converting said first and second chrominance signals from a digital format back to an analog format.

28. A method for decoding video image information recorded in both even and odd field lines on a recording medium wherein luminance information is recorded for both the even and odd field lines, first chrominance information is recorded for the odd field lines, and second chrominance information is recorded for the even field lines comprising the steps of:

converting: the recorded luminance information to electronic luminance signals in a select order of field lines including converting all of either the even or odd field lines and then converting all of the remaining odd or even field lines; the first chrominance information to first electronic chrominance signals in synchronism with the conversion of said luminance signals for said odd field lines; the second chrominance information to second chrominance signals in synchronism with the conversion of said luminance signals for said even field lines; the second chrominance information to said second chrominance signals and thereafter interpolating odd field lines from said second chrominance signals in synchronism with the conversion of said luminance information for said odd field lines; and, said first chrominance information to said first chrominance signals and thereafter interpolating even field lines from said first chrominance signals in synchronism with the conversion of said luminance information for said even field lines; and

matrixing said luminance signals for said odd and even field lines, said first and second chrominance signals and said interpolated chrominance signals for said odd and even lines to provide electronic information color component signals from which a visible image of the recorded information may be made wherein said luminance and said first and second chrominance signals including said interpolated chrominance signals are selectively matrixed to provide red, green and blue color component signals in accordance with the equations:

red = luminance + first chrominance, green = luminance − 0.509(first chrominance) − 0.194(second chrominance), blue = luminance + second chrominance.

* * * * *

EXHIBIT 52

United States Patent [19]

Beaulier

[11] **Patent Number: 4,695,876**

[45] **Date of Patent: Sep. 22, 1987**

[54] **METHOD AND APPARATUS FOR THE EXTRACTION OF LUMINANCE INFORMATION FROM A VIDEO SIGNAL USING A FIELD STORE**

[75] Inventor: **Daniel A. Beaulier**, Menlo Park, Calif

[73] Assignee: **Ampex Corporation**, Redwood City, Calif

[21] Appl No: **885,992**

[22] Filed: **Jul. 15, 1986**

Related U.S. Application Data

[63] Continuation of Ser No 482,118, Apr 4, 1983, abandoned

[51] **Int. Cl.**[4] **H04N 9/78**

[52] **U.S. Cl.** **358/31**

[58] **Field of Search** 358/31, 13

[56] **References Cited**

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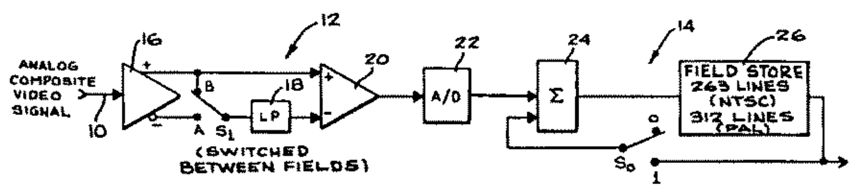
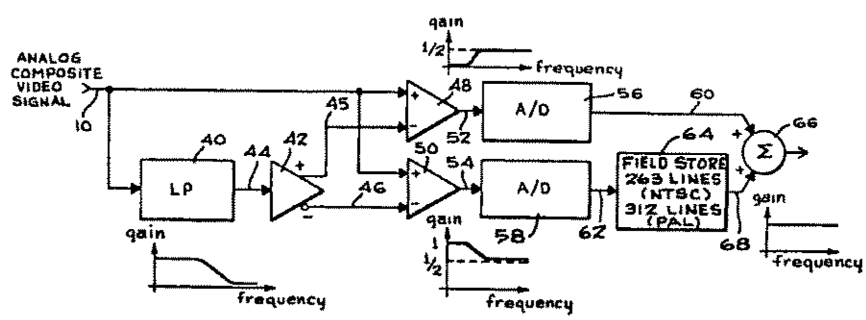
Primary Examiner—John W Shepperd
Attorney, Agent, or Firm—Donald L Bartels, Bradley A Perkins, Joel D Talcott

[57] **ABSTRACT**

A method and apparatus for the extraction of luminance information from an analog composite video signal Non-luminance information in the video signal is 180° out of phase between adjacent lines in adjacent fields of a video signal Appropriately filtered adjacent fields are summed to cancel non-luminance information, leaving the desired luminance information A field store is employed to allow the summing of adjacent fields by storing the present field to be summed with the next field of the video signal

13 Claims, 4 Drawing Figures





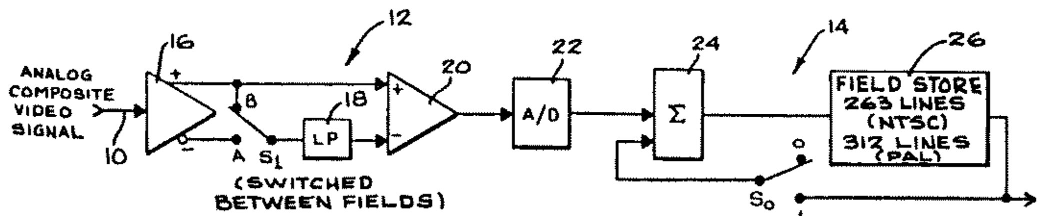


FIG_1

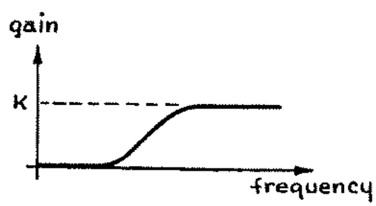


FIG_3

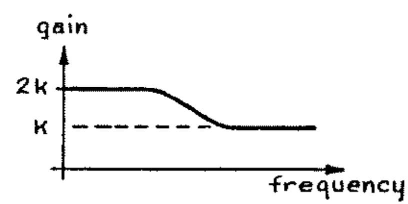


FIG_2

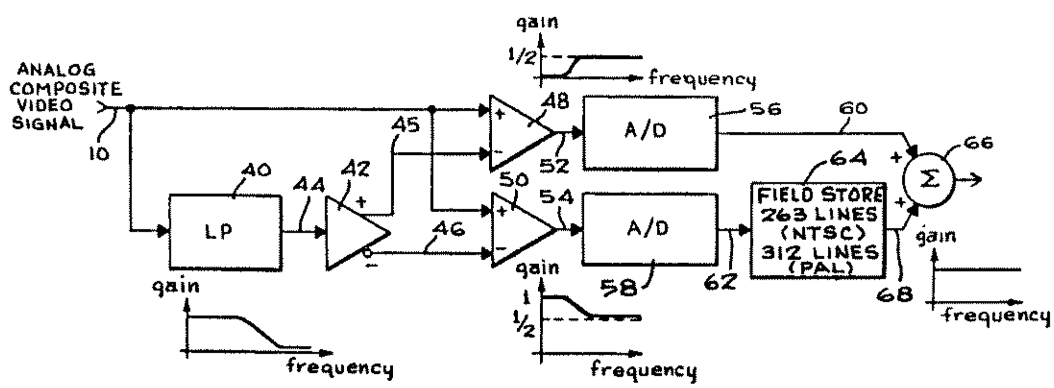

ANALOG COMPOSITE VIDEO SIGNAL
10
40
LP
44
42
45
46
48
50
52
54
A/D
A/D
56
58
60
62
64
FIELD STORE
263 LINES
(NTSC)
312 LINES
(PAL)
66
Σ
68
gain
1/2
frequency
gain
frequency
gain
1
1/2
frequency
gain
frequency

FIG_4

METHOD AND APPARATUS FOR THE EXTRACTION OF LUMINANCE INFORMATION FROM A VIDEO SIGNAL USING A FIELD STORE

This is a continuation of co-pending application Ser No 482,118 filed on Apr 4, 1983, now abandoned

BACKGROUND OF THE INVENTION

This invention relates in general to signal processing with reference to a composite video signal, and more particularly to the extraction of luminance information from a video signal on which color information has been encoded

A broad range of signal processing is frequently performed on video signals upon which color information has been encoded This includes not only the storing and subsequent retrieval of the video information from a wide variety of media, including magnetic tape, disk, and semiconductor memory devices, but also real time algorithmic type processing including color correction and noise reduction In connection with such signal processing, it is freqeuntly desirable to reduce the video information contained in the composite video signal into its respective component forms, and thereafter perform the desired processing upon the respective components

Basically speaking, a television picture is composed of a plurality of horizontal lines, each line containing color and brightness information for the respective portions along its length The total number of said horizontal lines are further subdivided into two groups, or fields in such a manner that the respective lines of each field vertically interlace to form a single picture, or frame The signal information for each location along each of said horizontal line is encoded in a single electronic signal commonly referred to as a composite video signal The composite video signal contains both color as well as black and white information The average DC level of said composite signal with reference to a horizontal line generally represents the corresponding black and white brightness information Color information is contained on a 3 58 MHz subcarrier signal which is superimposed on said DC level In particular, the amplitude of said subcarrier contains color saturation information, and the phase angle of said subcarrier with reference to a reference subcarrier contains the respective color information As color information is phase encoded on the 3 58 MHz subcarrier, a 3 58 MHz reference signal is transmitted with each line of video information for reference purposes The DC level of said video signal is generally referred to as containing the luminance information, and the 3 58 MHz subcarrier is generally referred to as containing the chrominance information

From a mathematical standpoint, the encoded color information present in the chrominance signal can be represented as a vector having a magnitude proportional to the amplitude of said subcarrier and a phase angle proportional to the phase of said 3 58 MHz with reference to said reference signal

In considering a composite video signal with reference to the frequency domain, the luminance signal would be composed of frequency components up to approximately 4 5 MHz As chrominance information is contained on the 3 58 MHz subcarrier, it is clear that most chrominance frequency information will be centered about 3 58 MHz From the foregoing it is apparent

that chrominance information is present within the same frequency spectrum as luminance information

In the processing of video signals, it is frequently desirable to extract the luminance and chrominance signal components from the composite video signal Thereafter signal processing can be performed upon the luminance and chrominance signal components directly, from which the composite video signal can be subsequently reconstructed

In dealing with the chrominance information, while said information is present in the amplitude and phase relations of the 3 58 MHz subcarrier, it is generally not convenient to perform the desired processing upon the chominance information in this form Rather it is preferable to obtain chrominance information in its respective component form, i e, the R - Y and B - Y components

Several techniques are commonly used to extract chominance and luminance information from a composite video signal In a first approach, a composite video signal is supplied to a bandpass filter having a center frequency of 3 58 MHz The output from said bandpass filter will consequently contain primarily chrominance information Luminance information can be thereafter derived by subtracting the output of the bandpass filter, i e, the chrominance, from the composite video signal, thereby yielding the luminance signal The respective R - Y and B - Y components are thereafter derived from the chrominance signal by a demodulation process In particular, as the R - Y and B - Y signals represent the orthogonal components of the chrominance signal, said components are generally derived by multiplying the chrominance signal by a second signal The R - Y component is generally derived by multiplying the said chrominance signal by a first reference signal having a frequency of 3 58 MHz The resultant signal from said multiplication process is thereafter supplied to a low pass filter the output of which represents the corresponding R - Y orthogonal component in an analog format In a similar fashion, the B - Y orthogonal component of chrominance is derived by multiplying the chrominance signal by a second reference signal having a frequency of 3 58 MHz and a phase difference from said first reference signal of 90° Thereafter the result of said second multiplication process is supplied to a low pass filter, the output of which is an analog signal representative of the B - Y orthogonal component of the chrominance signal

While the above approach will produce a luminance signal as well as the respective orthogonal components of the chrominance signal, there are a number of shortcomings In particular, due to the fact that the luminance signal can have components in the frequency spectrum occupied by the chrominance signal, the bandpass filter employed in the above approach has limited abilities to effectively separate the luminance signal from the chrominance signal Consequently luminance signal components are frequently present in the R - Y and B - Y output from the demodulation process

An improved approach over the single bandpass system above described employs the operation of a comb filter In particular the output from the bandpass filter is thereafter supplied as an input to a comb filter The output from the comb filter represents the desired chrominance signal which is subsequently used for subtraction from the composite signal to generate a luminance signal, as well as the chrominance input for the demodulation process

A comb filter may be implemented by taking advantage of certain phase relationships present in the 3 58 MHz subcarrier between subsequent lines, fields and frames in a composite video signal generated in accordance with the National Television System Committee standard RS-170A as promulgated by the Electronic Industries Association, or the Phase Alternating Line standard, hereinafter referred to as NTSC and PAL respectively

In a composite video signal, the phase relation of 3 58 MHz subcarrier will change between subsequent lines in a field, as well as adjacent lines in adjacent fields In particular there is a 180° phase shift of the 3 58 MHz subcarrier between corresponding points on adjacent lines within the same field in a composite video signal generated according to the NTSC standard, and a 90° phase shift between corresponding points on adjacent lines within the same field in a composite video signal generated according to the PAL standard It is also observed that a 180° phase shift exists between corresponding points on certain adjacent lines between two fields in a video signal produced according to both the NTSC and PAL standard This phase shift can be used to an advantage in the extraction of chrominance information from a composite video signal

In the foregoing approach employing a bandpass filter to produce a chrominance signal, by supplying the output from said bandpass filter to a delay means capable of delaying said chrominance signal by an amount equal in time to one horizontal line in the NTSC system, or two horizontal lines in the PAL system and thereafter subtracting the results from the output from the bandpass filter, the result of said process will be a signal from which luminance components have been removed and chromiance components present therein will have been doubled This signal can then be used as an input to the demodulator for subsequent production of the R - Y and B - Y orthogonal components of the chrominance signal, as well as subtracted from the composite video signal produce a luminance signal

While this approach can be used to produce performance superior to that achievable with the use of a bandpass filter alone, a number of shortcomings nevertheless remain These shortcomings generally relate to the point in the video signal at which said 180° phase shift occurs In the NTSC system, the point at which a 180° phase shift has occurred is available at the corresponding point in either the subsequent line in the same field, or the corresponding point on an adjacent line in the next succeeding field In this regard it will be particularly observed that the amount of change in luminance between subsequent lines in the same field and adjacent lines in a subsequent field can vary considerably This problem is further compounded in the PAL system wherein the phase shift between corresponding points on subsequent lines in a single field is 90° Consequently the amount of delay necessary for the video signal in the PAL system required for a 180° phase reversal is two horizontal lines within a field Clearly the amount of change in luminance possible between two horizontal lines in the PAL system further compounds the problem In the NTSC and PAL systems, however, there is a 180° phase shift between corresponding points on certain adjacent lines between adjacent fields Consequently by delaying the chrominance signal by an amount in time equal to one field, the necessary 180° phase shift is possible with a minimum change in luminance in both the NTSC and PAL systems However,

this approach requires storing a substantial amount of video information, as the required delay is one field of 263 lines in the NTSC systems and one field of 312 lines PAL systems

In the past, the storage of a complete field of video information has been achieved by digitizing the composite video signal and storing the results therefrom in a storage device This storage device is commonly a semiconductor memory device It will however be noted in this approach that as the composite video signal was initially digitized in the composite form, subsequent operations performed thereon necessarily must be performed in the digital domain In particular, the mathematical operation of substracting the digitized form of the component composite video information from the digitized video composite signal stored in the storage means to produce a chrominance signal, as well as the implementation of the subsequent bandpass filter must be performed in the digital domain The digital results of the signal subsequent to the bandpass filter would represent chrominance information which could thereafter be subtracted from the digitized composite video signal to produce a signal representative of chrominance However, the R - Y and B - Y orthogonal components of the chrominance signal must still be extracted from the digitized chrominance signal As this necessarily requires a multiplication process, implementation of same in the digital domain is particularly complex and requires extensive hardware Efforts in this area are documented in Croll, M G, 1980, *A Digital Storage System For an Electronic Colour Rostrum Camera*, IEE Conference Publication No 191, 252-255, and Clarke, C K P, 1982, *High Quality Decoding For PAL Inputs to Digital YUV Studieos*, IEE Conference Publication No 220, 363-366

Consequently while it is observed that minimum changes in luminance will occur between subsequent lines on adjacent fields, implementation of this approach in the past has necessited extensive amounts of hardware to perform the required digital signal processing

SUMMARY

In the present invention, the disadvantages and limitations present in prior art techniques for the extraction of luminance information employing the digitizing of the analog composite video signal for storage in a frame store, and the subsequent required implementation of a bandpass filter in the digital domain have been obviated

In the present invention a field store is employed to obtain the necessary 180° phase reversal from the non delayed video signal between adjacent lines in adjacent fields thereby minimizing the effects of changes in luminance In particular the composite analog video signal is supplied to a low pass filter having a cut off frequency below the 3 58 MHz subcarrier frequency The output of the low pass filter is supplied to an amplifier having differential outputs The noninverting output from said amplifier is supplied as a first input to a first summer The composite analog video signal is supplied as the second input to the first summer The output from the first summer is subsequently supplied as the input to a first analog to digital converter The inverting output from said amplifier is supplied as a first input to a second summer The analog composite video signal is supplied as a second input to the second summer The output from the second summer is supplied as an input to a second analog to digital converter The output from the second analog to digital converter is supplied as an

input to a storage means which functions to store the digitized output from the second summer for one complete field The output from said storage means is thereafter supplied as a first input to a third summer The output from said first analog to digital converter is supplied as a second input to the third summer The output from the third summer represents luminance information in a digital format Consequently luminance information is continuously extracted from a composite analog video signal

In a particular embodiment of the present invention, luminance information may be separated from an analog composite video signal and digitized for storing on an individual field basis for use in an electronic storage system wherein a single field of video information is stored In this regard, an inverted video signal is developed from the composite video signal The inverted signal is low pass filtered above a selected frequency in the band width of the composite signal during the first field The color subcarrier frequency is subtracted from the composite signal during the first field and is converted to a first digital signal During the second field the noninverted video signal is low pass filtered and this filtered signal is subtracted from the composite signal and converted to a second digital signal The first and second digital signals are added which digitally encodes the luminance information of the composite video signal

DESCRIPTION OF FIGURES

FIG 1 illustrates in a functional block form a method and apparatus for the extraction of luminance information from an analog composite video signal on a field basis in accordance with the present invention

FIG 2 illustrates the frequency response of a portion of the circuit illustrated in FIG 1 with switch S1 in position A

FIG 3 illustrates for frequency response of a portion of the circuit illustrated in FIG 1 with switch S1 in position B

FIG 4 illustrates in a functional block form a method and apparatus for the extraction of luminance information from an analog composite video signal on a continuous basis in accordance with the present invention

DETAILED DESCRIPTION

FIG 1 illustrates a source of analog composite video signal 10, an analog processing section 12 and a two field comb filter 14 for the extraction of luminance information from an analog composite video signal in accordance with the present invention Analog processing section 12 includes differential output amplifier 16, a switch S1, a lowpass filter 18, a differential input amplifier 20 and an analog to digital conveter 22 Filter 14 includes a digital summer 24 and a digital field store 26

Source 10 applies the analog composite video signal to differential output amplifier 16 Differential output amplifier 16 develops a non-inverted video signal at its non-inverting output and an inverted video siganl at its inverting output It is clear that the inverted video signal appearing at the inverting output from differential output amplifier 16 is the same signal as the non-inverted video signal which appears at the non-inverting video output of amplifier 16, only shifted in phase by 180°. The non-inverted signal is applied to the non-inverting input of differential input amplifier 16 and to a pole B of switch S1 The inverted signal is applied to a pole A of switch S1 Switch S1 selectively switches the

signal occurring at either pole A or B for application to a low pass filter 18 Low pass filter 18 attenuates the signals applied thereto above a selected frequency, the selected frequency being less than the frequency of the color subcarrier of the composite video signal The attenuated signal developed by low pass filter 18 is applied to the inverting input of differential input amplifier 20 Differential input amplifier 20 subtracts the signal occurring at its inverting input from the signal applied to its non-inverting input and develops a subtracted signal The subtracted signal is applied to analog to digital conveter 22 Analog to digital converter 22 converts the subtracted signal into a digital signal The digital signal is applied to a first input of digital summer 24 The output of digital summer 24 is coupled to an input of field store 26 The output of field store 26 is coupled to a second input of digital summer 24

The chroma separation process requires two fields to complete During the first field, switch S1 is placed in position A, switch S0 is placed in position 0

Placing S1 in position A will filter the analog video signal producing an output from analog processing section 12 according to the transfer function K(1 LP (s)), where LP(s) is the response of lowpass filter 18, and where K includes any gain factors of amplifier 16 and 20 For low frequencies, LP(s)=1, producing a gain of 2K For frequencies above the cutoff frequency of lowpass filter 18, LP(s)=0, producing a gain of K This is shown symbolically in FIG 2 Signal components near subcarrier will be subjected to a gain of K, while low frequency luminance components will be subjected to a gain of 2K

The filtered anlog signal is thereafter converted to a digital form by analog to digital converter 22 and stored in field store 26 At the end of the first field, switch S1 is placed in position B, switch So is placed in position 1

Placing S1 in position B will filter the analog video signal according to the transfer function K(1−LP(s) For the low frequencies, LP(s)=1, producing a gain of 0, for frequencies above the cutoff frequency of filter 18, LP(s)=0, producing a gain of K This is shown symbolically in FIG 3 Signal components near subcarrier will again be subjected to a gain of K, but low frequency luminance components will be blocked

Adder 24 will combine the filtered digitized signal of field 2 with the data being output from field store 26 As noted earlier, luminance information tends to repeat in phase from field to field For any such signal, the net transfer function at the output of adder 24 would be the sum of the individual transfer functions realized by analog processing section 12 during the two fields In particular this would be $K(1+LP(s))+K(1-LP(s)=2K$ This illustrates that all information which is in phase from field to field will be subjected to a uniform gain

As noted earlier, subcarrier information reverses phase from field to field It is also possible for luminance information to change phase from field to field The transfer function for any signal which changes phase from field to field is the difference of the above two transfer functions, $K(1+LP(s))-(K1-LP(s))=2K(LP(s))$ This illustrates that information which changes phase from field to field is not passed in the same manner as information which is field coherant, but instead is lowpass filtered

Thus the net effect of the process is to remove from the composite signal only the high frequency components which change from field to field, that includes

chroma information In-phase high frequency components and all low frequency components regardless of phasing, pass with the identical gain of 2K

The output of adder **24** is rewritten into field store **26** until the end of the second field, at which time field store **26** will contain chroma free data suitable for recording or other purposes To achieve this effect, field store **26** must be 263 lines long for an NTSC system and 312 lines long for a PAL system

It will be observed that the above approach is insensitive to small variations in analog parameters In particular small changes in response to the pass band in the low pass filter will effect only diagonal luminance components In a similar manner imblance in the differential gains present with reference to amplifier **16** and **20** will only cause small differences in gain between in phase and diagonal luminance information As the desired separation requires only that the low pass filter have a response near zero at the subcarrier frequency, it is clear that the foregoing practical limitations have minimal effect

It is likewise observed from the foregoing that as the low pass filter **18** as well as signal processing elements consisting of amplifiers **16** and **20** operate in the analog domain, and are present in the analog signal processing prior to the conversion to the digital domain, it is not necessary in the present invention to implement the functions of the low pass filter in the digital domain This results in significant simplification of the required signal processing

The principles of the present invention can be further extended to the extraction of luminance information from a composite analog signal on a continuous rather than a field basis A functional block diagram of such a device incorporating the present invention is illustrated in FIG 4

Referring now to FIG 4 composite video signal **10** is applied to low pass filter **40** and as a first input to differential amplifier **42** Low pass filter **40** functions to pass frequencies below the frequency of the 3 54 MHz subcarrier in output signal **44** Output signal **44** from low pass filter **40** is supplied as an input to amplifier **42** Amplifier **42** produces a differential output signal having a non-inverting output **44** and an inverting output **46** The non-inverting output **46** from amplifier **44** is applied as a second input to differential amplifier **48** The inverting output from amplifier **42** is supplied as a second input to differential amplifier **50** The composite video signal **10** is supplied as a first input to differential amplifier **50** Differential amplifier **48** and **50** function to produce output signals **52** and **54** respectively equal to the sum of input signals **10** and **44** and **10** and **46** respectively The output **52** from differential amplifier **48** is thereafter supplied as an input to the first analog to digital converter **56** The output **54** from differential amplifier **50** is supplied as an input to second analog to digital converter **58** Analog to digital converters **56** and **58** function to convert their respective analog input signals **52** and **54** respectively to the corresponding digital representation **60** and **62** respectively The output **62** from analog to digital converter **58** is supplied as an input to field store means **64** Field store means **64** functions to store the digital input **62** thereto Field store means **64** may be implemented in numerous manners including semiconductor memories Field store **64** functions to store the digital representation of the analog signal **54** corresponding to a field of video information according to the PAL video standard, and the

NTSC video standards To achieve this effect, field store **26** must be 263 lines long for an NTSC system and 312 lines long for a PAL system The output signal **60** from first analog to digital converter **56** is supplied as a first input to summing means **66** The output **68** from field store means **64** is supplied to a second input to summing means **66** Summing means **66** functions to perform the addition in a digital format of the respective inputs thereto producing an output signal **68** equal to the sum of the respective input signals thereto The output signal **68** represents luminance information in a digital format

The above described method and apparatus to extract luminance information from a composite video signal operates as follows

The output of differential amplifiers **48** and **50** will consist of analog video filtered information according to the functions K(1=LP(s)) and K (1+LP(s)) respectively After digitization the output of differential amplifier **50** is delayed by for an interval corresponding to one field, 263 lines for an NTSC system and 312 lines for a PAL system, and added to the digitized output of differential amplifier **48** by means of adder **66** It is clear that the result of this addition is identical to that of the previous discussions, specifically that field coherant information is passed with a gain of 2K while information which reverses phase from field to field is low pass filtered according to the function 2K (LP(S)) The distinction between the implementation of FIG 1 and FIG 4 is that the implementation of FIG 4 results in a continuous process whereas that of FIG 1 does not Thus the implementation of FIG 1 is suitable primarily for freezing action at some point in time, whereas the implementation of FIG 4 would be suitable for decoding of normal real time television images on a continuous basis

While the foregoing has disclosed a method and apparatus for the extraction of luminance information from a composite video signal employing digital techniques, many modifications to the foregoing would be apparent witnout departing from the inventive concepts embodied herein to one having ordinary shill in the art Consequently the foregoing descriptions are not be interpreted in a limiting manner Rather, the inventive concept herein is to be limited only by the following claims

What is claimed is

1 Apparatus for extracting luminance information from a video signal composed of first and second fields of a plurality of frequency components wherein a plurality of high frequency components, containing non-luminance information, are out of phase by 180° from the first to the second fields, the apparatus comprising

first filter means responsive to the video signal of the first field for analogly producing a filtered first field signal comprised of those signals having frequency components below the selected frequency increased in amplitude by twice a constant gain and those signals having frequency components above the selected frequency increased in amplitude by the constant gain,

second filter means responsive to the video signal of the second field for analogly producing a filtered second field signal comprised of those signals having frequency components below the selected frequency decreased in amplitude to zero and those signals having frequency components above the

selected frequency increased in amplitude by the constant gain,

analog-to-digital conversion means responsive to the filtered first field signal for producing a digitized first field signal that is a digital representation of the filtered first signal, and responsive to the filtered second field signal for producing a digitized second field signal that is the digital representation of the filtered second field signal,

delay means responsive to the digitized first field signal for digitally producing a delayed first field signal that is the digitized first field signal delayed by a period of a field, and

summing means responsive to the delayed first field signal and the digitized second field signal for extracting the luminance information by digitally summing the delayed first field signal and the digitized second field signal so that out of phase non-luminance components cancel

2 The apparatus of claim 1 wherein the first filter means comprises

a differential output amplifier responsive to the video signal of the first field for producing an inverted video signal and a non-inverted video signal, the inverted video signal being identical to the non-inverted video signal except shifted in phase by 180°;

a low pass filter responsive to the inverted video signal for attenuating signals above the selected frequency to produce low pass filtered video signal, and

a differential input amplifier responsive to the non-inverted video signal applied to its non-inverted input and responsive to the low pass filtered video signal applied to its inverted input to produce the filtered first field signal by subtracting the inverted low pass filtered video signal from the non-inverted video signal

3 The apparatus of claim 1 wherein the second filter means comprises

a differential output amplifier responsive to the video signal of the second field for producing a non-inverted video signal,

a low pass filter responsive to the non-inverted video signal for attenuating signals above the selected frequency to produce low pass filtered video signal, and

a differential input amplifier responsive to the non-inverted video signal applied to its non-inverted input and responsive to the low pass filtered video signal applied to its inverted input to produce the filtered first field signal by subtracting the low pass filtered video signal from the noninverted video signal

4 The apparatus of claim 1 wherein the selected frequency is less than a color subcarrier frequency of the video signal

5 The apparatus of claim 1 wherein the delay means comprises a field store

6 Apparatus for extracting luminance information from a video signal composed of successive fields of a plurality of frequency components wherein a plurality of high frequency components, containing non-luminance information, are out of phase by 180° from field to successive field, the apparatus comprising

filtering means responsive to the video signal for analogly producing a first and second filter output signal so that the first filter output signal contains the low frequency components present in the video signal and the second filter output signal contains the low frequency components present in the video signal shifted in phase by 180°;

a first summing means responsive to the video signal and the first filter output signal for analogly producing a first output signal equal to the difference between the video signal and the first filter output signal,

a second summing means responsive to the video signal and the second filter output signal for analogly producing a second output signal equal to the difference between the video signal and the second filter output signal,

a first conversion means for producing a first digitized signal which is a digital representation of the first output signal,

a second conversion means for producing a second digitized signal which is a digital representation of the second output signal,

a delay means responsive to the second digitized signal for digitally producing a delayed signal which is delayed by the period of a field, and

summing means responsive to the delayed signal and the first digitized signal for extracting the luminance information by digitally summing the delayed signal and the first digitized signal so that out of phase non-luminance components cancel

7 The apparatus of claim 6 wherein the filter means comprises

low pass filter means responsive to the video signal for analogly producing a filtered signal, and

amplifier means responsive to the filtered signal for producing a first and second signal so that the first signal is identical to the filtered signal and the second signal is shifted in phase by 180° from the filtered signal

8 The apparatus of claim 6 wherein the delay means comprises a field store

9 Apparatus for extracting luminance information from first and second television fields of an analog video signal composed of a plurality of frequency components, said fields of video information composed of lines of video information, wherein a plurality of low frequency components present in the analog video signal are out of phase by 180° from said first to said second fields, said apparatus comprising

filter means responsive to the first and second television field defining an analog video signal for analogly producing a filtered output signal so that the filtered output signal comprises only those frequency components present in the analog video signal above a selected frequency and attenuated by one half for the second filtered output signal defining the first television field, and those frequency components present in the analog video signal above the selected frequency are attenuated one half, and those frequency components below the selected frequency are not attenuated, for the first filtered output signal defining the second television field,

analog-to-digital conversion means responsive to the first and second filtered output signals for respectively producing a first and second digital signal in a digital format,

delay means responsive to said second digital signal for digitally delaying said second digital signal by a period of one field to produce a delayed signal, and

summing means responsive to the first digital signal and to the delayed signal for extracting luminance information by digitally summing the delayed signal and the first digital signal so that out of phase non-luminance components cancel

10 Apparatus for producing luminance information from a first and second television field of an analog video signal composed of a plurality of frequency components, said apparatus comprising

amplifier means responsive to the analog video signal for producing a first and second amplified signal so that the first amplified signal is equal to the analog video signal and the second amplified signal is equal to the analog video signal shifted in phase by 180°;

filter means responsive to the second amplified signal on the first television field and responsive to the first amplified signal on the second television field for producing a filter output signal from which frequency components originally present in the filter input signal above a selected frequency have been removed,

difference means responsive to the first amplified signal and the filter output signal respectively for producing a difference output signal equal to the difference between the first amplified signal and the filtered output signal, the first amplified signal having an amplitude of zero below the selected frequency and having an amplitude equal to that of the second amplified signal above the selected frequency, and below the selected frequency the second amplified signal having an amplitude of twice the amplitude of the first and second amplified signals above the selected frequency,

analog-to-digital conversion means responsive to the difference output signal for producing the difference output signal in a digital format,

summing means responsive to the difference output signal in a digital format and a difference output signal in a digital format delayed in time by a constant time delay for producing a digital summed output signal equal to the difference output signal in a digital format for the first television field and equal to the sum of the difference output signal in a digital format and the difference output signal in a digital format delayed in time by a constant time delay for the second television field, and

delay means responsive to the digital summed output signal for producing the luminance information composed of the sum of the difference output signal in a digital format and the difference output signal in a digital format delayed in time by a constant time delay, said constant time delay such that adjacent lines of the first digitized signal and the second delayed digital signal are out of phase when summed

11 Method for extracting luminance information from a video signal composed of first and second fields of a plurality of frequency components wherein a plurality of high frequency components, containing non-luminance information, are out of phase by 180° from the first to the second fields comprising the steps of

analogly producing a filtered first field signal comprised of those signals having frequency components below the selected frequency increased in amplitude by twice a constant gain and those signals having frequency components above the selected frequency increased in amplitude by the constant gain in response to the video signal of the first field,

analogly producing a filtered second field signal comprised of those signals having frequency components below the selected frequency eliminated and those signals having frequency components above the selected frequency increased in amplitude by the constant gain in response to the video signal of the second field,

producing a digitized first field signal that is a digital representation of the filtered first field signal, and responsive to the filtered second field signal for producing a digitized second field signal that is the digital representation of the filtered second field signal,

digitally producing a delayed first field signal that is the digitized first field signal delayed by a period of a field, and

digitally summing the delayed first field signal and the digitized second field signal so that out of phase non-luminance components cancel so as to extract the luminance information

12 Method of extracting luminance information from a video signal composed of successive fields of a plurality of frequency components wherein a plurality of high frequency components, containing non-luminance information, are out of phase by 180° from field to successive field comprising the steps of

analogly producing a first and second filter output signal so that the first filter output signal contains the low frequency components present in the video signal and the second filter output signal contains the low frequency components present in the video signal shifted in phase by 180°;

analogly producing a first output signal equal to the difference between the video signal and the first filter output signal,

analogly producing a second output signal equal to the difference between the video signal and the second filter output signal,

producing a first digitized signal which is a digital representation of the first output signal,

producing a second digitized signal which is a digital representation of the second output signal,

digitally producing a delayed signal which is delayed by the period of a field, and

digitally summing the delayed signal and the first digitized signal so that out of phase non-luminance components cancel so as to extract the luminance information

13 A method for producing luminance information from a first and second television field from an analog video signal composed of a plurality of frequency components, comprising the steps of

filtering the analog video signal for the second television field to produce a second field filtered output signal comprising only those frequency components present in the analog video signal above a selected frequency and attenuated by one half,

filtering the analog video signal for the first television field to produce a first field filtered output signal comprising those frequency components present in the analog video signal below a selected frequency and those frequency components present in the analog video signal above a selected frequency attenuated by one half,

converting the first field filtered output signal and the second field filtered output signal to a first field

filtered digital output signal having a digital format representative of the first field filtered signal, and a second field filtered digital output signal having a digital format representative of the second field filtered signal respectively, and

adding the second field filtered digital output signal to the first field filtered digital output signal delayed in time by a constant amount to produce summed digital output signal, said constant time delay such that adjacent lines of the first digitized signal and the second delayed digital signal are out of phase when summed

* * * * *

EXHIBIT 53

SEALED DOCUMENT

EXHIBIT 54

Kodak EasyShare
DX7630 zoom digital camera

User's guide

www.kodak.com

For interactive tutorials, www.kodak.com/go/howto

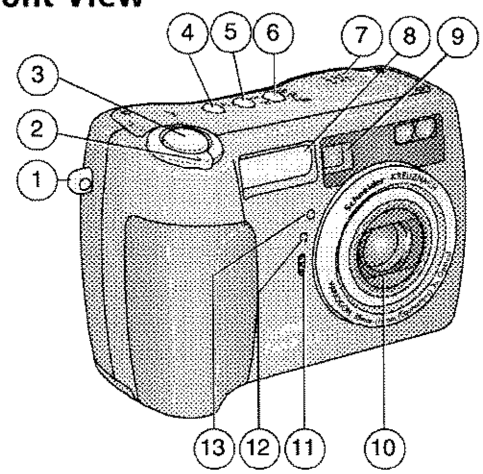
For help with your camera, www.kodak.com/go/dx7630support

Eastman Kodak Company
343 State Street
Rochester, New York 14650

All screen images are simulated.

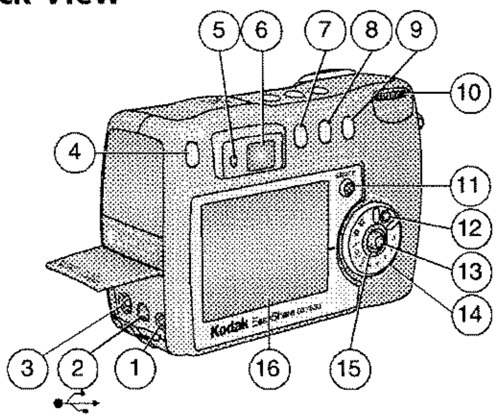
P/N 4J1082

Top, Front View



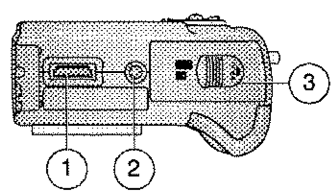
1 Wrist strap post
2 Zoom (Wide angle/Telephoto); Magnify (when Reviewing pictures)
3 Shutter button
4 Flash Setting button
5 Close-up/Landscape button
6 Exposure Bracketing/Burst button
7 Speaker
8 Flash unit
9 Viewfinder
10 Lens
11 Microphone
12 Light sensor
13 Self Timer/Video light

Side, Back View



1 A/V Out, for television viewing
2 USB Port
3 DC-In (5V)
4 Display/Info button
5 Ready light
6 Viewfinder
7 Delete button
8 Menu button
9 Review button
10 Jog dial
11 Share button
12 Mode dial lock
13 Joystick - move / / OK - press in
14 Mode dial
15 Power ring
16 Camera screen (LCD)

Bottom View



1 Dock connector
2 Tripod socket/locator for EasyShare camera dock or printer dock
3 Battery door, MMC/SD card slot

Table of contents

Changing the slide show display interval

The default interval setting displays each picture for 5 seconds. You can increase the display interval up to 60 seconds.

1 On the Slide Show menu, move the joystick ▲/▼ to highlight Interval, then press the OK button.
2 Select a display interval.
   To scroll through the seconds quickly, hold the joystick ▲/▼.
3 Press the OK button.
   The interval setting remains until you change it.

Running a continuous slide show loop

When you turn on Loop, the slide show is continuously repeated.

1 On the Slide Show menu, move the joystick ▲/▼ to highlight Loop, then press the OK button.
2 Move the joystick ▲/▼ to highlight On, then press the OK button.
   The slide show repeats until you press the OK button or until battery power is exhausted.

Displaying pictures and videos on a television

You can display pictures and videos on a television, computer monitor, or any device equipped with a video input. (Image quality on a television screen may not be as good as on a computer monitor or when printed.)

NOTE: Ensure that the Video Out setting (NTSC or PAL) is correct (see page 26). The slide show stops if you connect or disconnect the cable while the slide show is running.

1 Connect the audio/video cable (included) from the camera video-out port to the television video-in port (yellow) and audio-in port (white). See your television user's guide for details.
2 Review pictures and videos on the television.

EXHIBIT 55

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EXHIBIT 56

IEEE Std 100-1977

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IEEE Standard Dictionary of Electrical and Electronics Terms

Second Edition

Frank Jay
Editor in Chief

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EXHIBIT
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vibrating-reed relay. A relay in which the application of an alternating or a self-interrupted voltage to the driving coil produces an alternating or pulsating magnetic field that causes a reed to vibrate and operate contacts. *See also:* **relay.** 259, 341

vibrating string accelerometer. A device that employs one or more vibrating strings whose natural frequencies are affected as a result of acceleration acting on one or more proof masses. 46

vibration. An oscillation wherein the quantity is a parameter that defines the motion of a mechanical system. *See also:* **oscillation.** 176

vibration detection system (protective signaling). A system for the protection of vaults by the use of one or more detector buttons firmly fastened to the inner surface in order to pick up and convert vibration, caused by burglarious attack on the structure, to electric impulses in a protection circuit. *See also:* **protective signaling.** 328

vibration meter. An apparatus including a vibration pickup, calibrated amplifier, and output meter for the measurement of displacement, velocity, and acceleration of vibrations. *See also:* **instrument.** 328

vibration relay. A relay that responds to the magnitude and frequency of a mechanical vibration. 103, 60, 202, 127

vibration test (rotating machinery). A test taken on a machine to measure the vibration of any part of the machine under specified conditions. 63

vibrato. A family of tonal effects in music that depend upon periodic variations in one or more characteristics of the sound wave. *Note:* When the particular characteristics are known, the term **vibrato** should be modified accordingly, for example, frequency **vibrato**; amplitude **vibrato**; phase **vibrato** and so forth. 176

vibrator (cable plowing). That device which induces the vibration in a vibratory plow. *See also:* **vibratory plow.** 52

vibratory isolation (cable plowing). Percentage reduction in force transmitted from vibration source to receiver by use of flexible mounting(s) (amount of isolation for a given unit varies with plow blade frequency). 52

vibratory plow (cable plowing). A plow utilizing induced periodic motion(s) of the blade in conjunction with drawbar pull for its movement through the soil. *Note:* Orbital and oscillating plows are types of vibratory plows that are commercially available. 52

vibropendulous error (accelerometer). A cross coupling rectification error caused by angular motion of the pendulum in a pendulous accelerometer in response to a linear vibratory input. The error varies with frequency and is maximum when the vibratory acceleration is applied in a plane normal to a pivot axis and at 45 degrees to the input axis. 46

video (1) **(television).** A term pertaining to the bandwidth and spectrum position of the signal resulting from television scanning. *Note:* In present usage, video means a bandwidth of the order of several megahertz, and a spectrum position that goes with a direct-current carrier. *See also:* **signal wave.** 328
(2) **(radar).** Refers to the signal after envelope or phase detection, which in early radar was the displayed signal. Contains the relevant radar information after removal of the carrier frequency. 13

video filter (non-real time spectrum analyzer). A post detection low-pass filter. 68

video-frequency amplifier. A device capable of amplifying such signals as comprise periodic visual presentation. *See also:* **television.** 111

video integration (electronic navigation). A method of utilizing the redundancy of repetitive video signals to improve the output signal-to-noise ratio, by summing successive signals. *See also:* **navigation.** 13, 187

video mapping (electronic navigation). The electronic superposition of geographic or other data on a radar display. *See also:* **navigation.** 187

video stretching (electronic navigation). The increasing of the duration of a video pulse. *See also:* **navigation.** 187

video-telephone call (telephone switching systems). A call between stations equipped to provide video-telephone service. 55

vidicon. A camera tube in which a charge-density pattern is formed by photoconduction and stored on that surface of the photoconductor that is scanned by an electron beam, usually of low-velocity electrons. *See also:* **television.** 178, 190

viewing area (oscilloscope). The area of the phosphor screen of a cathode-ray tube that can be excited to emit light by the electron beam. *See:* **oscillograph; screen, viewing.** 184

viewing time (storage tubes). The time during which the storage tube is presenting a visible output corresponding to the stored information. *See also:* **storage tube.** 174, 190

viewing time, maximum usable (storage tubes). The length of time during which the visible output of a storage tube can be viewed, without rewriting, before a specified decay occurs. *Note:* The qualifying adjectives maximum usable are frequently omitted in general usage when it is clear that maximum usable viewing time is implied. *See also:* **storage tube.** 174, 190

virtual cathode (potential-minimum surface) (electron tubes). A region in the space charge where there is a potential minimum that, by reason of the space charge density, behaves as a source of electrons. *See also:* **electronic tube.** 244, 190

virtual duration (of a peak of a rectangular-wave current or voltage impulse) (surge arresters). The time during which the amplitude of the wave is greater than 90 percent of its peak value. 308, 62

virtual duration of wave front impulse (surge arrester). The virtual value for the duration of the wave front is as follows. (1) For voltage waves with wave front durations less than 30 μs, either full or chopped on the front, crest, or tail, 1.67 times the time for the voltage to increase from 30 to 90 percent of its crest value. (2) For voltage waves with wave front durations of 30 or more μs, the time taken by the voltage to increase from actual zero to maximum crest value. (3) For current waves, 1.25 times the time for the current to increase from 10 to 90 percent of crest value. *See also:* **surge arrester.** 2

virtual front time. *See:* **virtual duration of wavefront impulse.**

virtual height (radio wave propagation). The apparent

signal. *See also:* accuracy rating of an instrument. 295

step speed adjustment (industrial control). The speed drive can be adjusted in rather large and definite steps between minimum and maximum speed. *See also:* electric drive. 206

step-stress test (reliability). A test consisting of several stress levels applied sequentially, for periods of equal duration, to a (one) sample. During each period a stated stress-level is applied and the stress level is increased from one step to the next. *See also:* reliability. 182, 164

step twist, waveguide (waveguide components). A waveguide twist formed by abruptly rotating about the waveguide longitudinal axis, one or more waveguide sections each nominally a quarter wavelength long. 166

step-up transformer. A transformer in which the energy transfer is from a lower voltage circuit to a higher voltage circuit. 53

step voltage (safety) (conductor stringing equipment). The potential difference between two points on the earth's surface, separated by a distance of one pace, that will be assumed to be one meter, in the direction of maximum potential gradient. *Note:* This potential difference could be dangerous when current flows through the earth or material upon which a workman is standing, particularly under fault conditions. *Syn:* step potential. *See also:* ground. 313, 45

step-voltage regulator. A small regulating transformer in which the voltage of the regulated circuit is controlled in steps by means of taps and without interrupting the load. *Note:* Such units are generally 833 kVA (output) and below, single-phase, or 2500 kVA (output) and below, three-phase. 53

step-voltage test (rotating machinery). A controlled overvoltage test in which designated voltage increments are applied at designated times. Time increments may be constant or graded. *See:* graded-time step-voltage test. *See also:* asynchronous machine; direct-current commutating machine. 63

step wedge* (television). *See:* gray scale. 163

* Deprecated

steradian (1) (metric practice). The solid angle which, having its vertex in the center of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere (ISO Recommendation R 31, part 1, second edition, December 1965). 21

(2) (laser-maser). (sr). The unit of measure for a solid angle. There are 4π steradians in a sphere. 363

stereophonic (adjective) (frequency modulation). Pertains to audio information carried by a plurality of channels arranged to afford the listener a sense of the spatial distribution of the sound sources. *Note:* A stereophonic receiver responds to both the L + R main channel and the L − R subcarrier channel of a composite stereophonic signal, so that the one output contains substantially only L information, and the other only R. In addition to the main channel, stereophonic program modulation requires transmission of a 19 kHz pilot signal and the sidebands of a suppressed 38 kHz subcarrier carrying L − R information. This combination is called the composite signal, and it may be used alone or with other subcarrier (SCA) signals to frequency modulate the RF carrier. After preemphasis, the left and right channels are added for main channel information. The right-channel program material is subtracted from the left to derive a difference signal that then amplitude modulates a 38 kHz subcarrier. The subcarrier is suppressed, divided by two, and transmitted as a 19 kHz pilot signal to facilitate demodulation of the suppressed carrier information at the receiver. 16

stick circuit. A circuit used to maintain a relay or similar unit energized through its own contact. 328

stickiness. The condition caused by physical interference with the rotation of the moving element. *See also:* moving element of an instrument. 280

sticking voltage (luminescent screen). The voltage applied to the electron beam below which the rate of secondary emission from the screen is less than unity. The screen then has a negative charge that repels the primary electrons. *See also:* cathode-ray tubes. 244, 190

stick operation (switching device) (hook operation). Manual operation by means of a switch stick. 103, 202, 27

stiction (1). The force in excess of the coulomb friction required to start relative motion between two surfaces in contact. 329

(2) (static friction) (industrial control). The total friction that opposes the start of relative motion between elements in contact. *See also:* control system, feedback. 219, 206

stiffness (industrial control). The ability of a system or element to resist deviations resulting from loading at the output. *See also:* control system, feedback. 56, 219, 206

stiffness coefficient. The factor K (also called spring constant) in the differential equation for oscillatory motion $M\ddot{x} + B\dot{x} + Kx = 0$. *See also:* control system, feedback. 56

stilb. The unit of luminance (photometric brightness) equal to one candela per square centimeter. *Note:* The name stilb has been adopted by the International Commission on Illumination (CIE) and is commonly used in European publications. In the United States and Canada the preferred practice is to use self-explanatory terms such as candela per square inch and candela per square centimeter. *See also:* light. 167

Stiles-Crawford effect. The reduced luminous efficiency of rays entering the peripheral portion of the pupil of the eye. *See also:* visual field. 167

stimulated emission (laser-maser). The emission of radiation at a given frequency caused by an applied external radiation field of the same frequency. 363

stimulus (industrial control). Any change in signal that affects the controlled variable; for example, a disturbance or a change in reference input. *See also:* control system, feedback. 219, 206, 54

stirring effect (induction heater usage). The circulation in a molten charge due to the combined forces of motor and pinch effects. *See also:* induction heating; motor effect; pinch effect. 14, 114

stop (limit stop). A mechanical or electric device used to limit the excursion of electromechanical equipment. *See also:* limiter circuit. *See also:* electronic analog computer. 9

stop band (circuits and systems). A band of frequencies that

a four-wire and two-wire circuit. 59

fovea. A small region at the center of the retina, subtending about two degrees, that contains only cones and forms the site of most distinct vision. *See also:* retina. 167

foveal vision. *See:* central vision.

FOW. *See:* transformer, oil-immersed.

fractional-horsepower brush (rotating machinery). A brush with a cross-sectional area of ¼ square inch (thickness × width) or less and not exceeding 1½ inches in length, but larger than a miniature brush and smaller than an industrial brush. *See:* brush (1) (electric machines). 63

fractional-horsepower motor. A motor built in a frame smaller than that of a motor of open construction having a continuous rating of 1 horsepower at 1700–1800 revolutions per minute. *See:* asychronous machine; direct-current commutating machine. 63

fractional-slot winding (rotating machinery). A distributed winding in which the average number of slots per pole per phase is not integral, for example 3⅖ slots per pole per phase. *See also:* asynchronous machine; direct-current commutating machine. 63

fragility (nuclear power generating stations) (seismic qualification of class 1E equipment). Susceptibility of equipment to malfunction as the result of structural or operational limitations, or both. 28, 31

fragility level (nuclear power generating stations) (seismic qualification of class 1E equipment). The highest level of input excitation, expressed as a function of input frequency, that an equipment can withstand and still perform the required Class 1E functions. 28, 31

fragility response spectrum (FRS) (nuclear power generating stations) (seismic qualification of class 1E equipment). A TRS (test response spectrum) obtained from tests to determine the fragility level of equipment. *See also:* test response spectrum. 28, 31

frame (1) (television). The total area, occupied by the picture, that is scanned while the picture signal is not blanked.

(2) (facsimile). A rectangular area, the width of which is the available line and the length of which is determined by the service requirements. 12, 178

(3) (test, measurement and diagnostic equipment). A cross section of tape containing one bit in each channel and possibly a parity bit. *Syn.* tape line. 54

(4) (data transmission). A set of consecutive digit time slots in which the position of each digit time slot can be identified by reference to a framing signal. 59

framed plate (storage cell). A plate consisting of a frame supporting active material. *See also:* battery (primary or secondary). 328

frame frequency (television). The number of times per second that the frame is scanned. *See also:* television. 328

frame, intermediate distributing. *See:* intermediate distributing frame.

frame, main distributing. *See:* main distributing frame.

frame rate (data transmission). The repetition rate of the frame. 59

frame ring (rotating machinery). A plate or assembly of flat plates forming an annulus in a radial plane and serving as a part of the frame to stiffen it. 63

frame size (low-voltage circuit breaker). A term which denotes the maximum continuous current rating in amperes for all parts except the coils of the direct-acting trip device. 103

frame split (rotating machinery). A joint at which a frame may be separated into parts. 63

frame synchronization (data transmission). The process whereby a given channel at the receiving end is aligned with the corresponding channel at the transmitting end. 59

framework (rotating machinery). A stationary supporting structure. 63

frame yoke (field frame) (rotating machinery). The annular support for the poles of a direct-current machine. *Note:* It may be laminated or of solid metal and forms part of the magnetic circuit. 63

framing (facsimile). The adjustment of the picture to a desired position in the direction of line progression. *See also:* recording (facsimile). 12

framing signal (facsimile). A signal used for adjustment of the picture to a desired position in the direction of line progression. *See also:* facsimile signal (picture signal). 12

Fraunhofer pattern (antenna). A radiation pattern obtained in the Fraunhofer region. *See also:* antenna. 179, 111

Fraunhofer region (1) (antenna). The region in which the field of an antenna is focused. *See:* far-field region. *See also:* antenna. 179, 111

(2) (data transmission). That region of the field in which the energy flow from an antenna proceeds essentially as though coming from a point source located in the vicinity of the antenna. *Note:* If the antenna has a well-defined aperture D in a given aspect, the Fraunhofer region in that aspect is commonly taken to exist at distances greater than $2D^2/\lambda$ from the aperture, being the wavelength. 59

free capacitance (1) (conductor). The limiting value of its self-capacitance when all other conductors, including isolated ones, are infinitely removed.

(2) (between two conductors). The limiting value of the plenary capacitance as all other, including isolated, conductors are infinitely removed. 210

free-code call (telephone switching systems). A call to a service or office code for which no charge is made. 55

free cyanide (electrodepositing solution) (electroplating). The excess of alkali cyanide above the minimum required to give a clear solution, or above that required to form specified soluble double cyanides. *See also:* electroplating. 328

free field. A field (wave or potential) in a homogeneous, isotropic medium free from boundaries. In practice, a field in which the effects of the boundaries are negligible over the region of interest. *Note:* The actual pressure impinging on an object (for example, electroacoustic transducer) placed in an otherwise free sound field will differ from the pressure that would exist at that point with the object removed, unless the acoustic impedance of the object matches the acoustic impedance of the medium. 176

free-field current response (receiving current sensitivity) (electroacoustic transducer used for sound reception). The ratio of the current in the output circuit of the transducer when the output terminals are short-circuited to the free-field sound pressure existing at the transducer location prior to the introduction of the transducer in the sound

storage-element equilibrium voltage, second-crossover (storage tubes). The storage-element equilibrium voltage at the second-crossover voltage. *See also:* charge-storage tube. 174, 190

storage integrator (analog computer). An integrator used to store a voltage in the hold condition for future use while the rest of the computer assumes another computer control state. *See also:* electronic analog computer. 9

storage life (gyro; accelerometer). The non-operating time interval under specified conditions, after which a device will still exhibit a specified operating life. *See:* operating life. 46

storage light-amplifier (optoelectronic device). *See:* image-storage panel.

storage medium. Any device or recording medium into which data can be stored and held until some later time, and from which the entire original data can be obtained. 224, 207

storage protection (computing systems). An arrangement for preventing access to storage for either reading or writing, or both. 77

storage, reservoir (electric power systems). The volume of water in a reservoir at a given time. 112

storage station. A hydroelectric generating station having storage sufficient for seasonal or hold-over operation. *See also:* generating station. 64

storage surface (storage tubes). The surface upon which information is stored. *See also:* storage tube. 174, 190

storage temperature (1) (power supply). The range of environmental temperatures in which a power supply can be safely stored (for example, −40 to +85 degrees Celsius). *See also:* power supply. 186
(2) (semiconductor device). The range of environmental temperatures in which a semiconductor device can be safely stored. 66
(3) (light emitting diodes) (T_{stg}). The temperature at which the device, without any power applied, is stored. 162

storage temperature range. The range of temperatures over which the Hall generators may be stored without any voltage applied, or without exceeding a specified change in performance. 107

storage time* (storage tubes). *See:* retention time, maximum; decay time. *See also:* storage time.

* Deprecated

storage tube. An electron tube into which information can be introduced and read at a later time. *Note:* The output may be an electric signal and/or a visible image corresponding to the stored information. 174, 190, 125

store. (1) To retain data in a device from which it can be copied at a later time. (2) To put data into a storage device. (3) British synonym for storage. *See also:* storage. 235, 210, 255, 77

store-and-forward switching (data communication). A method of switching whereby messages are transferred directly or with interim storage, each in accordance with its own address. *See also:* packet switching. 12

store-and-forward switching system (telephone switching systems). A switching system for the transfer of messages, each with its own address or addresses, in which the message can be stored for subsequent transmission. 55

stored energy indicator (power switchgear). An indicator which visibly shows that the stored energy mechanism is in the charged or discharged position. 103

stored-energy operation. Operation by means of energy stored in the mechanism itself prior to the completion of the operation and sufficient to complete it under predetermined conditions. *Note:* This kind of operation may be subdivided according to: (1) How the energy is stored (spring, weight, etcetera); (2) How the energy originates (manual, electric, etcetera); (3) How the energy is released (manual, electric, etcetera). 103, 202

stored logic (telephone switching systems). Instructions in memory arranged to direct the performance of predetermined functions in response to readout. 55

stored program (telephone switching systems). A program in memory that a processor can execute. 55

stored-program computer. A digital computer that, under control of internally stored instructions, can synthesize, alter, and store instructions as though they were data and can subsequently execute these new instructions. 255, 77

stored program control (telephone switching systems). A system control using stored logic. 55

stored-program switching system (telephone switching systems). An automatic switching system having stored program control. 55

storm guys. Anchor guys, usually placed at right angles to direction of line, to provide strength to withstand transverse loading due to wind. *See also:* tower. 64

storm loading. The mechanical loading imposed upon the components of a pole line by the elements, that is, wind and/or ice, combined with the weight of the components of the line. *Note:* The United States has been divided into three loading districts, light, medium, and heavy, for which the amounts of wind and/or ice have been arbitrarily defined. *See also:* cable; open wire. 328

straggling, energy (semiconductor radiation detectors). The random fluctuations in energy loss whereby those particles having the same initial energy lose different amounts of energy when traversing a given thickness of matter. (This process leads to the broadening of spectral lines.) 23, 118, 119

straight-cut control system (numerically controlled machines). A system in which the controlled cutting action occurs only along a path parallel to linear, circular, or other machine ways. 224, 207

straightforward trunking (manual telephone switchboard system). That method of operation in which the *A* operator gives the order to the *B* operator over the trunk on which talking later takes place. 328

straight joint (1) (transmission and distribution). A joint used for connecting two lengths of cable in approximately the same straight line in series. *Note:* A straight joint is made between two like cables, for example, between two single-conductor cables, between two concentric cables, or between two triplex cables. *See:* branch joint; cable joint; reducing joint. 64
(2) (power cable joints). A cable joint used for connecting two lengths of cable, each of which consists of one or more conductors. 34

straight-line coding (computing systems). Coding in which loops are avoided by the repetition of parts of the coding when required. 255, 77

straight-seated bearing (rotating machinery) (cylindrical bearing). A journal bearing in which the bearing liner is

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